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NEW CHAPTERS IN THE WARFARE OF SCIENCE.

XIX.—FROM CREATION TO EVOLUTION.

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PART III.

THEOLOGICAL AND SCIENTIFIC THEORIES OF AN EVOLUTION IN ANIMATED NATURE.

WE have seen, thus far, how there came into the thinking of mankind upon the visible universe and its inhabitants the idea of a creation virtually instantaneous and complete, and the conception of a Creator in human form with human attributes, who spoke matter into existence literally by the exercise of His throat and lips, and who shaped and placed it with His hands and fingers.

We have seen that this view came from far; that it existed in the Chaldæo-Babylonian civilization and probably in others of the earliest date known to us; that its main features passed thence into the sacred books of the Hebrews and then into the early Christian Church, by whose theologians it was developed through the middle ages and maintained during the modern period.

But, while this idea was thus developed by a succession of noble and thoughtful men through thousands of years, another conception—to all appearance equally ancient—was developed, sometimes in antagonism to it, sometimes mingled with it: the conception of all living beings as wholly or in part the result of a growth process—of an evolution.

This idea, in various forms, became a powerful factor in nearly all the greater ancient theologies and philosophies. For very

widespread among the early peoples who attained to much thinking power was a conception that the universe arose from a watery chaos, and that its inhabitants were produced by sea and on land in obedience to a divine fiat.

This is clearly seen in the same records of Chaldæo-Babylonian thought deciphered in these latter years, to which reference has been made in previous chapters. In these we have a watery chaos which, under divine action, brings forth the earth and its inhabitants; first the sea animals and then the land animals, the latter being separated into three kinds, substantially as recorded afterward in the Hebrew accounts. At the various stages in the work the Chaldæan Creator pronounces it "beautiful," just as the Hebrew Creator in our own later account pronounces it "good."

In both accounts there is placed over the whole creation a solid, concave firmament; in both, light is created first and the heavenly bodies are afterward placed "for signs and for seasons"; in both the number seven is especially sacred, giving rise to a sacred division of time and to much else. It may be added that, with many other features in the Hebrew legends evidently drawn from the Chaldæan, the account of the creation in each is followed by a legend regarding "the fall of man" and a deluge, many details of which clearly passed in slightly modified form from the Chaldæan into the Hebrew accounts.

It would have been a miracle indeed if these primitive conceptions, wrought out with so much poetic vigor in that earlier civilization on the Tigris and Euphrates, had failed to influence the Hebrews, who, during the most plastic periods of their development, were under the tutelage of their Chaldæan neighbors. Since the researches of Layard, George Smith, Oppert, Schrader, Sayce, and their compeers, there is no longer a reasonable doubt that this ancient view of the world, elaborated if not originated in that earlier civilization, came thence as a legacy to the Hebrews, who wrought it in a somewhat disjointed shape and in a form mainly monotheistic into the poetic whole which forms one of the most precious treasures of ancient thought preserved in the book of Genesis.

Thus it was that, while the idea of a simple material creation literally by the voice, hands, and fingers of the Creator became, as we have already seen, the starting-point of a powerful stream of theological thought, and while this stream was swollen from age to age by contributions from the fathers, doctors, and learned divines of the Church, Catholic and Protestant, there was poured into it this lesser current, always discernible and at times clearly separated from it—a current of belief in a process of evolution.

The Rev. Prof. Sayce, of Oxford, than whom no English-speaking scholar carries more weight in a matter of this kind, has

recently declared his belief that the Chaldæo-Babylonian theory was the undoubted source of the similar theory propounded by the Ionic philosopher Anaximander, in the sixth century, the Greek thinkers deriving this view from the Babylonians through the Phœnicians; and he also allows that from the same source its main features were adopted into both the accounts given in the first of our sacred books, and in this general view the most eminent Christian Assyriologists concur.

It is true that each of these sacred accounts of ours contradicted the other. In that part of the first or Elohistic account given in the first chapter of Genesis the *waters* bring forth fishes, marine animals, and birds (Genesis, i, 20); but in that part of the second or Jehovistic account given in the second chapter of Genesis both the land animals and birds are declared to have been created not out of the water, but "*out of the ground*" (Genesis, ii, 19).

The dialectic skill of the fathers was easily equal to explaining away this contradiction between these two legends as regards the origin of birds; but the old current of thought, strengthened by both these accounts, arrested their attention, and, passing through the minds of a succession of the greatest men of the Church, influenced theological opinion deeply, if not widely, for ages in favor of an evolution theory.

This ancient idea that the animals and man were produced by lifeless matter at the divine command "in the beginning" was afterward supplemented by the idea, strengthened doubtless by Aristotle, that some of the lesser animals, especially the insects, were produced by a sort of later evolution, being evoked after the original creation from various sources, but chiefly from matter in a state of decay.

As typical examples of this thought we may note the view taken by St. Basil the Great in the fourth century. Discussing the work of creation, he declares that, at the command of God, "the waters were gifted with productive power"; "from slime and muddy places frogs, flies, and gnats came into being"; and he finally declares that the same voice which gave this energy and quality of productiveness to earth and water shall be similarly efficacious until the end of the world.

This idea of the great father of the Eastern Church took even stronger hold on the great father of the Western Church. For St. Augustine, so fettered usually by the letter of the sacred text, broke from his own famous doctrine as to the acceptance of Scripture and spurned the generally received belief of a creative process like that by which a toymaker brings into existence a box of playthings. In his great treatise on Genesis he says: "To suppose that God formed man from the dust with bodily hands is

very childish. . . . God neither formed man with bodily hands nor did He breathe upon him with throat and lips."

Augustine then suggests the adoption of the old emanation or evolution theory, adding that "certain very small animals may not have been created on the fifth and sixth days, but may have originated later from putrefying matter," and argues that, even if this be so, God is still their creator.

He dwells upon such a potential creation as involved in the actual creation, and speaks of animals "whose numbers the after-time unfolded."

In his great treatise on the Trinity—the work to which he devoted the best thirty years of his life—we find the full growth of this opinion. He develops at length the view that in the creation of living beings there was something like a growth—that God is the ultimate author, but works through secondary causes, and finally argues that certain substances are endowed by God with the power of producing certain classes of plants and animals.*

This idea of a development apart from the original creation and by secondary causes was helped in its growth by a theological exigency. More and more as the organic world was observed, no matter how imperfectly, the vast multitude of petty animals, winged creatures, and "creeping things" was instinctively felt to be a strain upon the sacred narrative. More and more it became difficult to reconcile the dignity of the Almighty with his work in bringing each of these creatures before Adam to be named; or to reconcile the human limitations of Adam with his work in

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* For the Chaldæan view of creation, see George Smith, Chaldæan Account of Genesis, New York, 1876, pp. 14, 15, and 64–86; also Lukas, as above; also Sayce, Religion of the Ancient Babylonians, Hibbert Lectures for 1887, pp. 371 and elsewhere; as to the fall of man, Tower of Babel, sacredness of the number seven, etc., see also Delitzsch, appendix to the German translation of Smith, pp. 305 *et seq.*; as to the almost exact adoption of the Chaldæan legends into the Hebrew sacred account, see all these, as also Schrader, Die Keilinschriften und das Alte Testament, Giessen, 1883, early chapters; also article Babylonia in the Encyclopædia Britannica; as to the similar approval of creation by the Creator in both accounts, see George Smith, p. 73; as to the migration of the Babylonian legends to the Hebrews, see Schrader, Whitehouse's translation, pp. 44, 45; as to the Chaldæan belief in a solid firmament, while Schrader in 1883 thought it not proved, Jensen in 1890 has found it clearly expressed—see his Kosmologie der Babylonier, pp. 9 *et seq.*, also pp. 304–306, and elsewhere. Dr. Lukas in 1893 also fully accepts this view of a Chaldæan record of a "firmament"; see Kosmologie, pp. 43, etc.

For the seven-day week among Chaldæans and rest on the seventh day, and the proof that even the name "Sabbath" is of Chaldæan origin, see Delitzsch, Beigaben zu Smith's Chald. Genesis, pp. 300 and 306; also Schrader; for St. Basil, see Hexæmeron and Homilies vii–ix; but, for the steadfastness of Basil's view in regard to the immutability of species, see a Catholic writer on Evolution and Faith in the Dublin Review for July, 1871, p. 13; for citations of St. Augustine on Genesis, see the De Genesi, lib. ii, cap. 14, in Migne, xxxiv, 188; lib. v, cap. 5 and cap. 23; and lib. vii, cap. 1; for the citations from his work on the Trinity, see his De Trinitate, lib. iii, cap. 8 and 9, in Migne, xlii, 877, 878.

naming "every living creature"; or to reconcile the dimensions of Noah's ark with the space required for preserving all of them, and the food of all sorts necessary for their sustenance, whether they were admitted by twos, as stated in one scriptural account, or by sevens, as stated in the other.

This latter subject gave especial trouble. Origen had dealt with it by suggesting that the cubit was six times greater than had been supposed. Bede explained Noah's ability to complete so large a vessel as the ark by supposing that he worked upon it during a hundred years; and, as to the provision of food taken into it, he declared that there was no need of a supply for more than one day, since God could throw the animals into a deep sleep or otherwise miraculously make one day's supply sufficient; he also lessened the strain on faith still more by diminishing the number of animals taken into the ark, supporting his view upon Augustine's theory of the later development of insects out of carrion.

Doubtless this theological necessity was among the main reasons which caused the theory—supported by St. Basil and St. Augustine—to be incorporated in the seventh century by St. Isidore of Seville into his great encyclopedic work which gave materials for thought on God and Nature to so many generations. He familiarized the theological world still further with the doctrine of secondary creation, giving such examples of it as that "bees are generated from decomposed veal, beetles from horseflesh, grasshoppers from mules, scorpions from crabs," and, in order to give still stronger force to the idea of such transformations, he dwells on the biblical account of Nebuchadnezzar, which appears to have taken strong hold upon mediæval thought in science, and declares that other human beings had been changed into animals, especially into swine, wolves, and owls.

This doctrine of after-creations went on gathering strength until, in the twelfth century, Peter Lombard, in his theological summary "The Sentences," so powerful in molding the thought of the Church, emphasizes the distinction between animals which spring from carrion and those which are created from earth and water; the former he holds to have been created "potentially," the latter "actually."

In the century following, this idea was taken up by St. Thomas Aquinas and virtually received from him its final form. In the "Summa," which remains the greatest work of mediæval thought, he accepts the idea that certain animals spring from the decaying bodies of plants and animals, and declares that they are produced by the creative word of God either actually or virtually. He develops this view by saying, "Nothing was made by God, after the six days of creation, absolutely new, but it was in some sense

included in the work of the six days"; and that "even new species, if any appear, have existed before in certain native properties, just as animals are produced from putrefaction."

The distinction thus developed between creation "causally" or "potentially," and "materially" or "formally," was made much of by commentators afterward. Cornelius a Lapide spread it by saying that certain animals were created not "absolutely," but only "derivatively," and this thought was still further developed three centuries later by Augustinus Eugubinus, who tells us that, after the first creative energy had called forth land and water, light was made by the Almighty, the instrument of all future creation, and that the light called everything into existence.

All this "science falsely so called," so sedulously developed by the great minds of the Church, and yet so futile that we might almost suppose that the great apostle, in a glow of prophetic vision, had foreseen it in his famous condemnation, seems at this distance very harmless indeed; yet, to many guardians of the "sacred deposit of doctrine" in the Church, even so slight a departure from the main current of thought seemed dangerous. It appeared to them like pressing the doctrine of secondary causes to a perilous extent; and about the beginning of the seventeenth century we have the eminent Spanish Jesuit and theologian Suarez denouncing it, and declaring St. Augustine a heretic for his share in setting it in motion.

But there was little danger to the older idea just then; the main theological tendency was so strong that the world kept on as of old; biblical theology continued to spin its own webs out of its own bowels, and all the lesser theological flies continued to be entangled in them; yet here and there stronger thinkers broke loose from this entanglement and helped somewhat to disentangle others.*

But while within the Church the current of evolutionary thought was almost lost to sight, it continued in its clearer form,

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* For Bede's view of the ark and the origin of insects, see his Hexæmeron, i and ii; for Isidore, see the Etymologiæ, xi, 4, and xiii, 22; for Peter Lombard, see Sent., lib. ii, dist. xv, 4 (in Migne, cxcii, 682); for St. Thomas Aquinas as to the laws of Nature, see Summa Theologica, i, Quæst. lxvii, art. iv; for his discussion on Avicenna's Theory of the origin of animals, see ibid., Quæst. lxxi, vol. i, pp. 1184 and 1185, of Migne's edit.; for his idea as to the word of God being the active producing principle, see ibid., i, Quæst. lxxi, art. i; for his remarks on species, see ibid., i, Quæst. lxxii, art. i; for his ideas on the necessity of the procreation of man, see ibid., i, Quæst. lxxii, art. i; for the origin of animals from putrefaction, see ibid., i, Quæst. lxxix, art. i, 3; for Cornelius a Lapide on the derivative creation of animals, see his In Genesim Comment., cap. i, cited by Mivart, Genesis of Species, p. 282; for a reference to Suarez's denunciation of the view of St. Augustine, see Huxley's Essays.

outside the Church, slowly to gain strength. On all sides, in every field, men were making discoveries which caused the general theological view to appear more and more inadequate.

In the first half of the seventeenth century Descartes seemed about to take for a time the leadership of human thought; his theories, however superseded now, gave a great impulse to investigation then. His genius in promoting an evolution doctrine as regarded the mechanical formation of the solar system was great, and his mode of thought strengthened the current of evolutionary doctrine generally; but his constant dread of persecution, both from Catholics and Protestants, led him steadily to veil his thoughts and even to suppress them. He had watched the Galileo struggle in all its stages; he had seen his own books condemned by university after university under the direction of theologians, and placed upon the index of prohibited books. Although he gave new and striking arguments to prove the existence of God, and humbled himself before the Jesuits, he was condemned by Catholics and Protestants alike; since Roger Bacon, perhaps, no great thinker had been so completely abased by theological oppression.

Near the close of the same century another great thinker, Leibnitz, though not propounding any full doctrine on evolution, gave it an impulse by suggesting a view contrary to the sacrosanct belief in the immutability of species—that is, to the pious doctrine that every species in the animal kingdom now exists as it left the hands of the Creator, the naming process by Adam, and the door of Noah's ark.

His punishment at the hands of the Church came a few years later, when, in 1712, the Jesuits defeated his attempt to found an Academy of Science at Vienna; the imperial authorities covered him with honors, but the priests—ruling in the confessionals and pulpits—would not allow him the privilege of aiding his fellowmen to ascertain God's truths revealed in Nature.

A few years after Leibnitz's death came in France a thinker in natural science of much less influence, but who made a decided step forward.

Early in the eighteenth century Benoist de Maillet, a man of the world, but a wide observer and close thinker upon Nature, began meditating especially upon the origin of animal forms, and was led into the idea of the transformation of species and so into a theory of evolution, which in some important respects anticipated modern ideas. He definitely conceived the production of existing species by the modification of their predecessors, and he plainly accepted one of the fundamental maxims of modern geology—that the structure of the globe must be studied in the light of the present course of Nature.

Unfortunately, De Maillet fell between two ranks of adversaries. On one side, the Church authorities denounced him as a free-thinker; on the other, Voltaire ridiculed him as a devotee. Feeling that his greatest danger was from the orthodox theologians, De Maillet endeavored to protect himself by disguising his name in the title of his book, and by so wording its preface and dedication that, if persecuted, he could declare it a mere sport of fancy; he therefore announced it as the reverie of a Hindu sage imparted to a Christian missionary. But this strategy availed nothing; he had allowed his Hindu sage to suggest that the days of creation named in Genesis might be long periods of time, and this, with other ideas of equally fearful import, was fatal. Though the book was in type in 1735, it was not published till 1748—three years after his death.

On the other hand, the heterodox theology of Voltaire was also aroused; and, as De Maillet had seen in the presence of fossils on high mountains a proof that these mountains were once below the sea, Voltaire recognized an argument for the deluge of Noah, and ridiculed the new thinker without mercy.

Hence it is that, between these two extremes of theology, De Maillet has received no recognition until very recently the greatest men of science in England and France have united in giving him his due. But his work was not lost, even in his own day; Robinet and Bonnet pushed forward victoriously on helpful lines.

In the second half of the eighteenth century a great barrier was thrown across this current—the authority of Linnæus. He was the most eminent naturalist of his time, a wide observer, a close thinker; but the atmosphere in which he lived and moved and had his being was saturated with biblical theology, and this permeated all his thinking.

He who visits the tomb of Linnæus to-day, entering the beautiful cathedral of Upsala by its southern porch, sees above it, wrought in stone, the Hebrew legend of creation. In a series of medallions the Almighty—in human form—accomplishes the work of each creative day. In due order he puts in place the solid firmament with the waters above it, the sun, moon, and stars within it, the beasts, birds, and plants below it, and finishes his task by taking man out of a little hillock of "the earth beneath," and woman out of man's side. Doubtless Linnæus, as he went to his devotions, often smiled at this childlike portrayal. Yet he was never able to break away from the idea it embodied. At times, in face of the difficulties which beset the orthodox theory, he ventured to favor some slight concessions; but what he might expect if he sanctioned the new view he learned to his cost: warnings came speedily both from the Catholic and Protestant sides.

At a time when the most eminent prelates of the older Church

were eulogizing debauched princes like Louis XV, and using the unspeakably vile casuistry of Suarez in the education of the priesthood as to the relations of men to women, the modesty of the papal authorities was so shocked by Linnæus's proofs of a sexual system in plants that for many years his writings were prohibited in the Papal States and in various other parts of Europe where clerical authority was strong enough to resist the new scientific current. Not until 1773 did one of the more broad-minded cardinals—Zelanda—succeed in gaining permission that Prof. Minasi should discuss the Linnæan system at Rome.

And Protestantism was quite as oppressive. In a letter to Eloius, Linnæus tells of the rebuke given to science by one of the great Lutheran prelates of Sweden, Bishop Svedberg. From various parts of Europe detailed statements had been sent to the Royal Academy of Science that water had been turned into blood, and well-meaning ecclesiastics had seen in this an indication of the wrath of God, certainly against the regions in which these miracles had occurred and possibly against the whole world. A miracle of this sort appearing in Sweden, Linnæus looked into it carefully and found that the reddening of the water was caused by dense masses of minute insects. News of this explanation having reached the bishop, he took the field against it; he denounced this scientific discovery as "a Satanic abyss" (*abyssum Satanæ*), and declared "The reddening of the water is not natural," and "when God allows such a miracle to take place Satan endeavors, and so do his ungodly, self-reliant, self-sufficient, and worldly tools, to make it signify nothing." In face of this onslaught Linnæus retreated; he tells his correspondent that "it is difficult to say anything in this matter," and shields himself under the statement "It is certainly a miracle that so many millions of creatures can be so suddenly propagated," and "it shows undoubtedly the all-wise power of the Infinite."

The great naturalist, now grown old and worn with labors for science, could no longer resist the contemporary theology; he settled into obedience to it, and continued to adhere to the doctrine that all existing species had been created by the Almighty "in the beginning," and that since "the beginning" no new species had appeared.

Yet even his great authority could not resist the swelling tide; more and more vast became the number of species, more and more incomprehensible under the old theory became the newly ascertained facts in geographical distribution, more and more it was felt that the universe and animated beings had come into existence by some process other than special creation, and the question was constantly pressing, "By what process?"

Throughout the whole of the eighteenth century one man was

at work on natural history who might have contributed much toward an answer to this question; the foremost was Buffon. His powers of research and thought were remarkable and his gift in presenting results of research and thought showed genius. He had caught the idea of an evolution in Nature and was likely to make a great advance with it; but he, too, was made to feel the power of theology.

While he gave pleasing descriptions of animals the Church petted him, but when he began to deduce truths of philosophical import the batteries of the Sorbonne were opened upon him; he was made to know that "the sacred deposit of truth committed to the Church" was, that "in the beginning God made the heavens and the earth"; and that "all things were made at the beginning of the world." For his simple statement of truths in natural science which are to-day truisms, he was dragged forth by the theological faculty, forced to recant publicly, and to print his recantation. In this he announced, "I abandon everything in my book respecting the formation of the earth, and generally all which may be contrary to the narrative of Moses." *

But all this triumph of the Chaldæo-Babylonian creation legends which the Church had inherited availed but little.

About the end of the eighteenth century fruitful suggestions and even clear presentations of this or that part of a large evolutionary doctrine came thick and fast, and from the most divergent quarters. Especially remarkable were those which came from Erasmus Darwin in England, from Maupertuis in France, from Oken in Switzerland, and, most brilliantly of all, from Goethe in Germany.

Two men among these thinkers must be especially mentioned—Treviranus in Germany and Lamarck in France; each independently of the other drew the world more completely than ever before in this direction.

From Treviranus came, in 1802, his work on biology, and in this he gave forth the idea that from forms of life originally simple had arisen all higher organizations by gradual development;

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* For Descartes in his relation to the Copernican theory, see Saisset, Descartes et ses Précurseurs; also Fouillée, Descartes, Paris, 1893, chaps. ii and iii; also other authorities cited in my chapter on Astronomy; for his relation to the theory of evolution, see the Principes de Philosophie, 3ème partie, § 45. For De Maillet, see Quatrefages, Darwin et ses Précurseurs français, chap. i, citing D'Archiac, Paléontologie, Stratigraphie, vol. i; also, Perrier, La Philosophie zoologique avant Darwin, chap. vi; also the admirable article, Evolution, by Huxley, in Encyc. Britan. The title of De Maillet's book is, Telliamed, ou Entretiens d'un Philosophe indien avec un Missionnaire français sur la Diminution de la Mer, 1748 and 1756. For Buffon, see the authorities previously given, also the chapter on Geology in this work. For the resistance of both Catholic and Protestant authorities to the Linnæan system and ideas, see Alberg, Life of Linnæus, London, 1888, pp. 143–147, and 237.

that every living creature has a capacity for receiving modifications of its structure from external influences; and that no species has become really extinct, but that it has passed into some other species. From Lamarck came about the same time his Researches, and a little later his Zoölogical Philosophy, which introduced a new factor into the process of evolution—the action of the animal itself in its efforts toward a development to suit new needs—and he gave as his principal conclusions the following:

New wants in animals give rise to new organs.

The development of these organs is in proportion to their employment.

New developments may be transmitted to offspring.

His well-known examples to illustrate these views, such as that of successive generations of giraffes lengthening their necks by stretching them to gather high-growing foliage, and of successive generations of kangaroos lengthening and strengthening their hind legs by the necessity of keeping themselves erect while jumping, provoked laughter, but the very comicality of these illustrations aided to fasten his main conclusion into men's memories.

In both these statements, imperfect as they were, great truths were embodied—truths which were sure to grow.

Lamarck's declaration, especially that the development of organs is in ratio to their employment, and his indications of the reproduction in progeny of what is gained or lost in parents by the influence of circumstances, entered as a most effective force into the development of the evolution theory.

The next great successor in the apostolate of this idea of the universe was Geoffroy Saint-Hilaire. As early as 1795 he had begun to form a theory that species are various modifications of the same type, and this theory he developed, testing it at various stages as Nature was more and more displayed before him. It fell to his lot to bear the brunt in a struggle against heavy odds which lasted many years.

For the man who now took up the warfare, avowedly for science but unconsciously for theology, was the foremost naturalist then living—Cuvier. His scientific eminence was deserved; the highest honors of his own and other countries were given him, and he bore them worthily. An Imperial Councilor under Napoleon; President of the Council of Public Instruction and Chancellor of the University under the restored Bourbons; Grand Officer of the Legion of Honor, a Peer of France, Minister of the Interior, and President of the Council of State under Louis Philippe, he was eminent in all these capacities, and yet the dignity given by such high administrative positions was as nothing compared to his leadership in natural science. Science throughout

the world acknowledged in him its chief contemporary ornament, and to this hour his fame rightly continues. But there was in him, as in Linnæus, a survival of certain theological ways of looking at the universe and certain theological conceptions of a plan of creation; it must be said, too, that while his temperament made him shy of new hypotheses, of which he had seen the birth and death of so many, his environment as a great functionary of state, honored, admired, almost adored by the greatest, not only in the state but in the Church, his solicitude lest science should receive some detriment by openly resisting the Church, which had recaptured Europe after the French Revolution and had made of its enemies its footstool—all these considerations led him to oppose the new theory. Amid the plaudits, then, of the foremost churchmen and laymen he threw across the path of the evolution doctrines the whole mass of his authority in favor of the old theory of catastrophic changes and special creations.

Geoffroy Saint-Hilaire stoutly withstood him, braving non-recognition, ill-treatment, and ridicule. Treviranus, afar off in his mathematical lecture room at Bremen, seemed simply forgotten.

But the current of evolutionary thought could not thus be checked; dammed up for a time, it broke out in new channels and in ways and places least expected; turned away from France, it appeared especially in England; great paleontologists and geologists arose there whose work culminated in that of Lyell. Specialists throughout all the world now became more vigorous than ever, gathering facts and thinking upon them in a way which caused the special creation theory to shrink more and more. Broader and more full became these various rivulets, soon to unite in one great stream of thought.

In 1813 Dr. Wells developed a theory of evolution by natural selection to account for varieties in the human race; about 1820 Dean Herbert, eminent as an authority in horticulture, avowed his conviction that species are but fixed varieties; in 1831 Patrick Matthews stumbled upon and stated the main doctrine of natural selection in evolution; and others, here and there, in Europe and America, caught an inkling of it.

But no one outside of a circle apparently uninfluential cared for these things: the Church was serene; on the continent it had obtained reactionary control of courts, cabinets, and universities; in England Dean Cockburn was denouncing Mary Somerville and the geologists to the delight of the established churchmen; and the Rev. Mellor Brown was doing the same thing for the edification of dissenters.

In America the mild suggestions of Silliman and his compeers were met by the protestations of the Andover theologians headed

by Moses Stuart. Neither of the great English universities, as a rule, took any notice of the innovators save by sneers.

To this current of thought there was joined a new element, when, in 1844, Robert Chambers published his Vestiges of Creation. The book was attractive and was widely read; in Chambers's view the several series of animated beings, from the simplest and oldest up to the highest and most recent, were the result of two distinct impulses, each given once and for all time by the Creator. The first of these was an impulse imparted to forms of life lifting them gradually through higher grades; the second was an impulse tending to modify organic substances in accordance with external circumstances; in fact, the doctrine of the book was evolution tempered by miracle, a stretching out of the creative act through all time—a pious version of Lamarck.

Two results followed—one mirth-provoking, the other leading to serious thought. As to the former, the theologians were greatly alarmed by the book; it was loudly insisted that it promoted atheism. Looking back along the line of thought which has since been developed, one feels that the Church ought to have put up public thanksgivings for Chambers's theory and public prayers that it might prove true. As to the serious result, it accustomed men's minds to a belief in evolution as in some form possibly or even probably true. In this way it was provisionally of service.

Eight years later Herbert Spencer published an essay contrasting the theories of creation and evolution, reasoning with great force in favor of the latter, showing that species had undoubtedly been modified by circumstances; but still only few and chosen men saw the significance of all these lines of reasoning which had been converging during so many years toward one conclusion.

On July 1, 1858, there were read before the Linnæan Society at London two papers—one presented by Charles Darwin, the other by Alfred Russel Wallace—and with the reading of these papers the doctrine of evolution by natural selection was born. Then and there a fatal breach was made in the great theological barrier of the continued fixity of species since the creation.

The story of these papers the scientific world knows by heart: how Charles Darwin, having been sent to the University of Cambridge to fit him for the Anglican priesthood, left it in 1831 to go upon the scientific expedition of the "Beagle"; how for five years he studied with wonderful vigor and acuteness the problems of life as revealed on land and at sea—among volcanoes and coral reefs, in forests and on the sands, from the tropics to the arctic regions; how, in the Cape de Verde and the Galapagos Islands, and in Brazil, Patagonia, and Australia he interrogated Nature with matchless persistency and skill; how he returned un-

heralded, quietly settled down to his work, and soon astonished the world with the first published results, such as his book on Coral Reefs, and the monograph on the Cirripedia; and, finally, how he presented his paper and followed it up with treatises which make him one of the great leaders in the history of human thought.

The scientific world realizes, too, more and more the power of character shown by Darwin in all this great career: the faculty of silence, the reserve of strength seen in keeping his great thought—his idea of evolution by natural selection—under silent study and meditation for nearly twenty years, giving no hint of it to the world at large, but working in every field to secure proofs or disproofs, and accumulating masses of precious material for the solution of the questions involved.

To one man only did he reveal his thought: to Dr. Joseph Hooker, to whom in 1844—under the seal of secrecy—he gave a summary of his conclusions. Not until fourteen years later occurred the event which showed him that the fullness of time had come, the letter from Alfred Russel Wallace, to whom, in brilliant researches during the decade from 1848 to 1858, in Brazil and in the Malay Archipelago, the same truth of evolution by natural selection had been revealed. Among the proofs that scientific study does no injury to the more delicate shades of sentiment is the well-known story of this letter. With it Wallace sent Darwin a memoir, which he asked him to present to the Linnæan Society; on examining it, Darwin found that Wallace had independently arrived at conclusions similar to his own—possibly had deprived him of fame; but Darwin was loyal to his friend, and his friend remained ever loyal to him. He publicly presented the paper from Wallace, and with it his own conclusions, and the date of this presentation—July 1, 1858—separates two epochs in the history, not merely of natural science, but of human thought.

In the following year, 1859, came the first installment of his thought in its fuller development—his work on The Origin of Species. In this, one at least of the great secrets at the heart of the evolutionary process, which had baffled the long line of investigators and philosophers from the days of Aristotle, was more broadly revealed. The effective mechanism of evolution was shown at work in three ascertained facts: in the struggle for existence among organized beings; in the survival of the fittest; and in heredity. These facts were presented with such wealth of minute research, wide observation, and patient collation, with such transparent honesty and judicial fairness, that they at once commanded the world's attention. It was the outcome of thirty years' work and thought by a worker and thinker of genius, but it was yet more than that—it was the outcome, also, of the work

and thought of another man of genius fifty years before. The book of Malthus on the Principle of Population, mainly founded on the fact that animals increase in a geometrical ratio, and therefore, unchecked, must encumber the earth, had been generally forgotten, and was only recalled to remembrance now and then with a sneer. But the genius of Darwin recognized in it a deeper meaning, and now the thought of Malthus was joined to the new current. Meditating upon it in connection with his own observations of the luxuriance of Nature, Darwin arrived at his doctrine of natural selection and survival of the fittest.

As the great dogmatic barrier between the old and new views of the universe was broken down, the flood of new thought pouring over the world stimulated and nourished strong growths in every field of research and reasoning; edition after edition of the book was called for; it was translated even into Japanese and Hindustani; the stagnation of scientific thought, which Buckle only a few years before had so deeply lamented, gave place to a widespread and fruitful activity; masses of accumulated observations, which had seemed stale and unprofitable, were made alive; facts formerly without meaning now found their interpretation. Under this new influence a vast army of young men took up every line of scientific investigation in every land. Epoch-making books appeared in all the great nations. Spencer, Wallace, Huxley, Galton, Tyndall, Tylor, Lubbock, Bagehot, Lewes, in England, and a phalanx of strong men in Germany, Italy, France, and America gave forth works which became authoritative in every department of biology. If some of the older men in France held back, overawed perhaps by the authority of Cuvier, the younger and more vigorous pressed on.

One source of opposition in America deserves to be especially mentioned—Louis Agassiz.

A great investigator, an inspired and inspiring teacher, a noble man, he had received and elaborated a theory of animated creation which he could not readily change. In his heart and mind still prevailed the atmosphere of the little Swiss parsonage in which he was born, and his religious and moral nature, so beautiful to all who knew him, was especially repelled by sundry evolutionists, who, in their zeal as neophytes, made proclamations having a decidedly irreligious if not immoral bearing. In addition to this was the direction his thinking had received from Cuvier; both these influences combined to prevent his acceptance of the new view.

He was the third great man who had thrown his influence as a barrier across the current of evolutionary thought. Linnæus in the second half of the eighteenth century, Cuvier in the first half and Agassiz in the second half of the nineteenth—all made

the same effort. Each remains great; but not all of them together could arrest the current. Agassiz's strong efforts throughout the United States, and indeed throughout Europe, to check it, really promoted it. From the great museum which he had founded at Cambridge, from his summer school at Penikese, from his lecture-rooms at Harvard and Cornell, his disciples went forth full of love and admiration for him, full of enthusiasm which he had aroused and into fields which he had indicated; but their powers, which he had aroused and strengthened, were devoted to developing the truth he failed to recognize; Shaler, Verrill, Packard, Hartt, Wilder, Jordan, and a multitude of others, and above all the son who bore his honored name, did justice to his memory by applying what they had received from him to research under inspiration of the new revelation.

Still another man deserves especial gratitude and honor in this great progress—Edward Livingston Youmans. He was perhaps the first in America to recognize the vast bearings of the truths presented by Darwin, Wallace, and Spencer. He became the apostle of these truths, sacrificing the brilliant career on which he had entered as a public lecturer, subordinating himself to the three leaders and giving himself to editorial drudgery in the stimulation of research and the announcement of results.

In support of the new doctrine came a world of new proofs; those which Darwin himself added in regard to the cross-fertilization of plants, and which he had adopted from embryology, led the way, and these were followed by the discoveries of Wallace, Bates, Huxley, Marsh, Cope, Leidy, Haeckel, Müller, Gaudry, and a multitude of others in all lands. The last theological efforts against these men we shall study in the next chapter.*

THE Royal Institution of Great Britain, in a memorial resolution to Professor Tyndall, adopted at a general meeting, speaks of him as one "who by his brilliant abilities and laborious researches nobly promoted the objects of the institution and conspicuously enhanced its reputation, while at the same time he extended scientific truth and rendered many new additions to natural knowledge practically available for the service of mankind."

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* For Agassiz's opposition to evolution, see the Essay on Classification, vol. i, 1857, as regards Lamarck, and vol. iii, 1860, as regards Darwin; also Silliman's Journal, July, 1860; also the Atlantic Monthly, January, 1874; also his Life and Correspondence, vol. ii, p. 647; also Asa Gray, Scientific Papers, vol. ii, p. 484. A reminiscence of my own enables me to appreciate his deep ethical and religious feeling. I was passing the day with him at Nahant in 1868, consulting him regarding candidates for various scientific chairs at the newly established Cornell University, in which he took a deep interest. As we discussed one after another of the candidates he suddenly said: "Who is to be your Professor of Moral Philosophy? That is a far more important position than all the others."

THE GUESTS OF THE MAYFLOWER.

By Prof. CLARENCE M. WEED.

NO native plant has so endeared itself to the New England heart as the mayflower. For two centuries it has been to old and young the sweetest of spring's harbingers as it pushed its dainty blossoms through the fallen leaves beside the lingering snow. It has charmed those fortunate ones who have wandered over the hills to find it, and has carried glad tidings to those compelled to stay at home. It has been constantly used to carry Cupid's message from youths to maidens—a custom which I like to fancy may have originated when, in the infancy of Plymouth, John Alden brought to Priscilla Mullens bunches of arbutus blossoms that spoke not only for themselves but also for the hand that plucked them.

But *Epigæa* is a plant of decided interest in itself apart from its associations. It was not originally designed as an emissary of

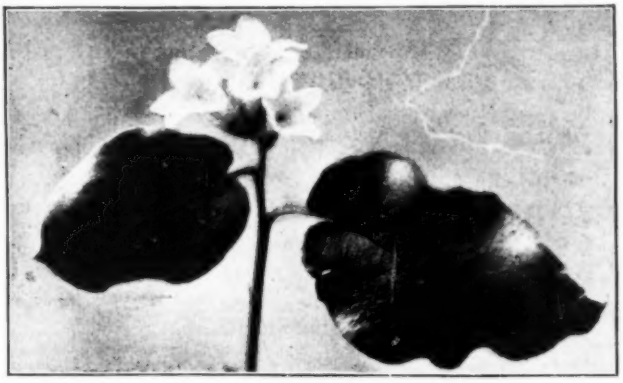

Fig. 1.—The Mayflower.

the goddess of love, and its beauty was primarily developed without reference to the æsthetic needs of the Pilgrims or their descendants. Long before the Mayflower reached Plymouth or Columbus landed at San Salvador—probably before the Indians arrived, and possibly before the glaciers came down from the north—the arbutus blossomed with each returning season and carried on the cycle of her existence as tranquilly as she does today. But her fragrance was by no means "wasted on the desert air," for she received then, as now, the tributes of a host of insect visitors that went about to do her unconscious bidding.

Although the trailing arbutus has been developing for so many centuries, it is still in a state of transition, and appears to be looking toward a goal which probably will not be fully reached

for centuries to come. Every one with the least knowledge of the vegetable world knows that the great majority of flowering plants have the stamens and pistils in the same blossom, although Nature generally devises some method of preventing self-pollination. Many species, however, bear the pistillate blossoms on one plant or part of the plant, and the staminate blossoms on another plant or part of the plant, relying on insects or the wind to carry the pollen from the latter to the former. But occasionally there occurs a species whose flowers are neither wholly one nor the other, being in a transition stage between the two. In this category we find the mayflower.

The examination of the structure of a dozen bunches of arbutus blossoms reveals a great variation in the relative conditions and positions of the stamens and pistils. In some specimens the anthers are completely abortive; in others only partially so; and in others in good condition, well filled with pollen grains. Two types of stigmas are also present: in some specimens the stigmas as a whole are broad and more or less flattened—spread out, so to speak—projecting at right angles to the style with the upper surface moist and glutinous; in others the stigmas are crowded into less space and project very little horizontally; they are drier and less glutinous, and evidently in a partially abortive condition. The perfect stigmas are usually associated with abortive anthers, and *vice versa*, so that many of the plants are already dioecious.

If the flowers are examined with reference to the length of the styles and filaments of the pistils and stamens, great variations will also be found. In some the stigmas are perfect and reach the mouth of the corolla; no anthers, and only rudiments of filaments are present. The variations I found on Blueberry Hill at Hanover, New Hampshire, may be epitomized as follows:

1. Stigmas perfect, reaching the mouth of the corolla; no anthers, and only rudiments of filaments present (Fig. 2, *a*).

2. Stigmas perfect, reaching the mouth of the corolla; anthers present, but abortive, reaching two thirds the way to the mouth of the corolla (Fig. 2, *b*).

3. Stigmas perfect, reaching half way to the mouth of the corolla; anthers abortive or absent, not reaching the stigmas.

4. Stigmas imperfect, anthers perfect; both reaching the mouth of the corolla.

5. Stigmas imperfect, anthers perfect; both reaching two thirds of the way from the base to the mouth of the corolla.

6. Stigmas imperfect, reaching slightly beyond the mouth of the corolla; anthers perfect, reaching to the mouth (Fig. 2, *c*).

The relative proportions of the different forms seem to vary with the locality. The majority of specimens I have studied belonged either in the first or fourth category. The arbutus at Han-

over is evidently tending strongly to a more perfect dicœcism When it finishes its task of eliminating the filaments as it has the anthers of the stamens in many of the pistillate blossoms, and gets rid of the superfluous pistils of the staminate blossoms, it will accomplish its purposes of reproduction with less waste than at present.

A plant in the condition of the arbutus may be said to be in a certain sense at a "parting of the ways." To attain the end of cross-fertilization—the carrying of the pollen from the stamens of one plant to the pistils of another—two methods appear to be open to it. It may, and in the case of many of the Blueberry Hill specimens evidently has, become more perfectly dicœcious by aborting the stamens on some plants and the pistils on others; or it might become dimorphous by developing perfect sexual organs

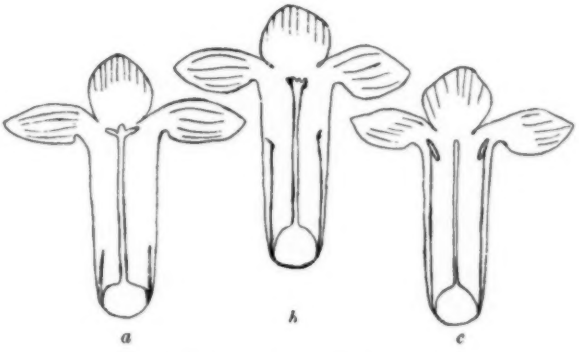

FIG. 2.—VARIATIONS OF THE MAYFLOWER.

in each blossom and having them at different heights—that is, having the stamens in one plant reach the mouth of the corolla and the pistil reach only half way to the mouth, while in another having the pistil long and the stamens short. The tendency toward dimorphism or trimorphism is shown by the varying lengths of the styles and filaments.

The blossoms of the common asparagus of our gardens show by their structure that they are in a transition stage somewhat similar to that of the arbutus. The staminate blossoms have rudimentary pistils and the pistillate blossoms rudimentary stamens, and sometimes a blossom is found which has both sets of organs in good condition—a reversion to an earlier condition of the plant.

The partridge berry,* a plant which has to contend with much the same external conditions as the arbutus, living in similar situations and remaining close to the ground, has adopted

* *Mitchella repens.*

dimorphism as its method of securing cross-fertilization. The beautiful white blossoms of this species open early in summer. The stamens of some individuals are exserted, with the stigmas below the mouth of the corolla, while in others these conditions are reversed. Another common example of a low-growing plant with dimorphous sexual organs is that of the familiar bluets.* The dainty blossoms of this species are small individually, but grow so abundantly on New England hillsides as often to color them like a light fall of snow. A sectional view of the two forms of flowers is shown in Fig. 3: *a* represents the long-styled form with the stamens in the lower portion of the corolla tube and the stigma exserted, while in *b* the stamens are near the mouth of the corolla and the stigma is below. These blossoms are mainly pollenized by small bees and butterflies, one of the commonest New England visitors being the meadow fritillary.† When an insect

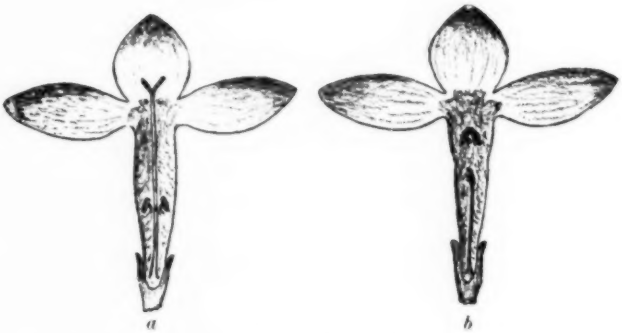

FIG. 3.—LONG-STYLED AND SHORT-STYLED FORMS OF HOUSTONIA

sucks the nectar from the base of the corolla of the short-styled blossom (*b*), it will get at a certain place on its tongue some of the pollen from the anthers. If next it visits a long-styled blossom (*a*), it will be likely to brush some of this pollen on to the exserted stigma, while a point near the tip of the tongue will receive a fresh supply of pollen grains. If now it again visits a short-styled blossom, this last-received pollen will be at the right elevation to be deposited on the included stigma. Consequently, cross-fertilization will almost certainly occur.

In the case of the mayflower it is evident that the structural conditions described above will necessitate for the production of seed the transportation of the pollen from the staminate to the pistillate blossoms. The only agents to be called into play for this errand are the insects and the wind. The structure of the plant shows that under any ordinary conditions the wind would

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* *Houstonia cærulea.* † *Brenthis bellona.*

not serve the purpose, so that the insects only are left. It might at first seem that so early in the spring as the mayflower appears there would be few insects abroad —not enough to accomplish the desired results. But centuries of experience have taught the plant that the nectar hidden beneath her blushing petals will attract many visitors. On Blueberry Hill the most useful and abundant visitor is the beautiful orange-banded bumblebee.* Dozens of the large females, which have wintered over in some sheltered nook, are usually present, busily gathering the nectar concealed in the bases of the corollas. Each bee stops but a few seconds at a flower, and visits on an average three or four bunches of blossoms a minute. After alighting either on a flower or the leaves, or the ground between, the bee crawls from blossom to blossom, poking its nose, so to speak, down under the leaves that none shall be missed, and often visiting a dozen heads before taking to wings again. When the wind blows hard—a frequent occurrence on such hilltops—Madame Bombus (these early spring forms are all females, the so-called queens) flies still more rarely, crawling long distances instead. The tongue of this bee is two fifths of an inch long, and its tip readily reaches the bottom of the corolla, being thrust quickly down between the hairs. There are generally several blossoms in a single head, and, as a rule, each is plundered before the visitor departs. I saw one bee visit six heads in ninety seconds, and another seven heads in the same length of time. On the supposition that there were five blossoms per head, the first bee was plundering twenty flowers a minute. Supposing that half of each hour was spent between

FIG. 4.—ORANGE-BANDED BUMBLEBEE.

FIG. 5.—BOMBUS BIFARIUS. Hind Leg.

* *Bombus bifarius* Cr.

the plants or going to the nest, the bee at this rate would visit six hundred blossoms an hour, or six thousand in a ten-hour day, if she should work so long. On the five acres of hilltop where my observations were carried on I judged that at least one hundred of these bees were at work each day. Supposing that they all worked at the above ratio, the mayflower would receive six hundred thousand daily visits. No doubt many of the blossoms are visited more than once each day, and the chances are certainly very good that each blossom will be visited at least once during the two weeks of its existence.

FIG. 6.—THE BEE FLY.

Although the orange-banded bumblebee is much the most abundant visitor, two other related species are often seen. The commoner of these is a large and handsome *Bombus*,* black, except for two broad yellow bands—one on the thorax and the other on the abdomen. The other, which is seldom seen, is called by entomologists *Bombus consimilis;* the thorax and front half of the abdomen are yellow, with the hinder portion of the abdomen black.

By watching any one of these bees closely, one can see it stop every few minutes to brush the pollen grains off from its tongue and head, but no attempt appears to be made to collect the pollen in the beautifully developed pollen baskets on the legs (Fig. 5). These bees evidently visit the arbutus for the nectar it furnishes.

Although the bumblebees are much the most numerous and important of the mayflower's invited guests, a few other insects are found among the visitors. A rather small, two-winged fly, with a hairy, yellow body and black-banded wings, often flashes, meteor-like, from blossom to blossom. This is the handsome bee fly of the genus *Bombylius*,† one of the earliest spring insects. It has a very long tongue, which readily reaches the bottom of the mayflower corollas. I saw one of these flies stop twenty seconds at a single flower; it thrust its tongue down on one side of the pistil, then drew it out and pushed it down in another place, repeating the operation four times.

FIG. 7.—SESIA MOTH.

During the warmest portions of the brightest days the beautiful sesia moths appear. They are sometimes called hummingbird moths, because of their resemblance when flying to a hum-

* *B. terricola.*

† *B. fratellus.*

ming bird, though the smaller of our species, the one I find visiting the arbutus,* is more suggestive of a bumblebee. They have long tongues, curled up when not in use, through which they suck the nectar of flowers. Unlike most moths, which fly at dusk or after dark, the sesias are abroad in the bright sunlight.

Occasionally one of the early spring butterflies, especially the American tortoise-shell † and the mourning cloak, ‡ may be seen hovering over the blossoms.

The insect visitors so far considered are all useful to the mayflower. They fly rapidly from head to head and plant to plant, carrying the pollen which sticks to them from the anthers of the staminate blossoms to the stigmas of the pistillate ones, thus causing the fertilization of the embryos and the development of seeds. But the surface of the rocky hillsides where *Epigæa* is most thoroughly at home swarms with ants of various species—wingless creatures that dearly love the nectar of flowers. These insects wander everywhere in search of food, and are often seen trying to get at the honey at the bottom of the mayflower corollas. Could they succeed, little would be left for other visitors, and consequently the ants would not only be of practically no value as pollen-carriers—for rarely would one chance to wander from a staminate to a pistillate blossom—but they would also prevent the visits of the useful bees and flies. The plant, however, has fenced out these and other similar unbidden guests by an elaborate *chevaux-de-frise*, composed of hairs projecting slightly upward from the inner surface of the corolla and the outer surface of the ovary and style. It is easy for a bee, moth, or fly to push its slender tongue down through these hairs to the base of the corolla, but an ant finds it very difficult to force its body down till its mouth is at the bottom.

FIG. 8.—SECTIONAL VIEW OF MAYFLOWER, SHOWING HAIRS.

THE silk spider of Madagascar spins golden-colored threads, strong enough, according to M. Maindron, to hold a cork helmet by. A single female of the species, in the breeding season, gave M. Camboné about three thousand metres of fine silken thread in about twenty seven days. Small textures woven of these threads are used by the natives for fastening flowers on sunshades and for other light purposes.

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* *Hemaris diffinis.* † *Aglais milberti.* ‡ *Vanessa antiopa.*

UP THE CHIMNEY.

By FRANK BOLLES.

LYING flat upon my back on my bedroom floor, with my head in the fireplace, pillowed upon the andirons, and my gaze directed intently up the chimney, I watched, hour by hour, the strange domestic doings of two of my tenants. The fireplace was so arranged, and its opening into the chimney so shaped, that I could see much of that part of the interior of the chimney which rose above me, leading toward the little patch of blue sky far away. The whole of the west wall of the black flue, and a little more than half of both the north and south walls, were visible to me. The surface of these walls was rough, having been daubed with mortar which formed undulations and ridges. The lower faces of these irregularities were soft, dull black, but the parts inclined toward the sky caught the glare of light from above and shone as though ebonized. About eight feet above me, as I lay in the second-story fireplace, something about the size of half a small saucer projected like a tree fungus from the northern wall of the flue. Its edges gleamed like silvery gelatin, and light shone through its fabric in many places. This fabric seemed to be made of dozens of small twigs matted and woven together in semi-saucer form, and held firmly in place by some translucent, gelatinous substance of a yellowish-white color. Masses of the same substance held the shallow nest in its place against the hard, cold wall of brick and mortar. Protruding from the nest were the long and slender wings of a bird, which was sitting snugly upon the structure, with her face turned directly to the bricks. The tapering wings crossed near the body, and their tips spread like a Y, under which a short, stiff, fan-shaped tail extended, for a part of the distance covered by the wings. These stiff tail feathers, kept spread all the time, terminated in sharp spines, readily discernible. Occasionally, as I watched, the sitting bird wriggled on her nest, and her wings moved restlessly.

Suddenly the column of air in the chimney was thrown into vibration, and a dull booming sound resulted. Something darkened the opening of the shaft, the interrupted light trembled in a confusing way; I was strongly inclined to get out from under, and found it impossible to avoid closing my eyes. Simultaneously with these disturbing events, a bird's voice in the chimney produced a series of rapid whistling or peeping notes, so mingled as to render the hearer uncertain as to the number of birds making them. A second bird had entered the chimney. Seen from outside, he had dropped into it, and, watched by perturbed vision

from below, he had come down backward, hovering and fluttering until, head toward the light, his tiny feet had caught in the mortar and every spine in his very brief tail had been braced against the same rough substance. Perfectly motionless, he clung to the black wall as a tree toad sticks to a tree trunk. His flat head, tiny beak, sooty brown coat, shining in the glare from the sky, did not combine well into a bird; in fact, nothing in their weird surroundings made these tenants seem akin to birds. They were more like bats.

Outside, the hot sunlight and hazy blue sky of early July hung over wood and meadow, lake and distant mountain. Butterflies fluttered and drifted in aimless flight over the sumacs, a humming bird buzzed in the deep blue larkspur flowers, barn swallows cut fanciful curves over the lake and back to their nest with its nestlings; while down in the shadowy fern land the veery's tremulous music told of coolness and comfort. How different this soot lined tube of brick, leading down through ever-darkening gloom into an unknown abyss of blackness and silence! How strange that this keen-eyed swift, which a moment ago was speeding through highest ether at a rate which no other bird can equal and maintain, should come back into this pit and call it his home! He spoke again, and once more the heavy air of the chimney responded to his whirring wings, as he dropped a little lower to the level of the nest, and turned his bright eyes inquiringly toward his mate. Her wings now moved, and she lifted herself away from the frail platform of glued twigs and stuck against the bricks a few feet distant. The male, raising his wings and keeping them moving. walked flylike to the nest and settled upon it. Instead of facing directly toward the north wall, he sat upon the nest at a different angle, so that his forked wings projected obliquely from the nest's edge. A moment later the female made the air throb and boom to her powerful flight as she flew toward and into the light.

Twenty minutes passed; the bird on the nest was restless, and squirmed in a way which suggested physical discomfort. Then he gave a low call; and a moment later darkness, hurried notes, and the fluttering of strong wings announced the mother-bird's return. She dropped down backward until close beside the nest, struck and clung to the bricks, and then, using her feet almost as well as though on level ground, gained the nest and pushed her way upon it, fairly forcing off her mate, who seemed to have no inclination to depart. Finally he moved, and, after a series of short upward flights, regained the sunlight, and was seen no more for three quarters of an hour. As the female settled herself upon the nest, a faint "cheeping" suggested that tiny life was stirring beneath her breast. Her position was the same which

she took in the first instance, her face being turned so directly toward the north wall that her tail projected at right angles from the nest. After seeing half a dozen exchanges in position made by the birds, I was satisfied that one parent, which I called the female, always sat straight upon the nest, and the other, which for the sake of distinguishing them I called the male, always sat obliquely.

To see only the bottom of the nest, yet to know that within it lay young swifts which were being fed in some way by their parents, was tantalizing. I recalled a former year, when I wished to secure a swift's nest with its full set of eggs, and so had kept watch of the nest; not by climbing to the chimney top and peering down, but by raising a small mirror, by whose aid I had seen the reflected nest from below. The mirror served its purpose a second time. I lashed it to the tip of a fishing rod, and pushed the slender joint up the chimney, adding first the middle joint and then the butt, in order to bring the glass well above the nest. Something white was in the nest—just what, I could not at first tell, for mortar dust had fallen into my eyes, and it was difficult to keep the glass still enough to see with my eyes blinking and weeping. The mother-bird had been driven from the nest by the appearance of the strange, misshapen thing which I had forced toward her from below, and she was now making short flights back and forth in the upper part of the chimney, producing sounds and sudden variations in light and darkness which would surely have frightened away any but a human intruder. Wiping my eyes and steadying the glass, I took a careful look at the contents of the nest. The white object, or at all events its whitest part, was an eggshell from whose opened halves a young bird was feebly trying to escape. Without waiting to see more, I withdrew the mirror from the chimney and removed all disturbing objects, myself included, from the fireplace. My heart reproached me. Had my violence driven the birds from their nest, thus making probable the death of the young at this trying crisis in their career? More than fifteen minutes passed before booming wings in the swift's grewsome nursery assured me that a parent had returned.

These events happened on Monday, and not until the following Saturday did I again intrude upon my batlike neighbors. Meanwhile I was not unaware of their near presence, for at all hours of the day and night the thunder of their wings and their high-pitched voices invaded my room. After exchanging places at intervals of from fifteen to forty-five minutes all day long, it seemed to my human intelligence that they might keep still at night. But no, during evening twilight, and at ten, twelve, one, and three o'clock, and then with tenfold energy between dawn

and six in the morning, they came and went, went and came with apparently sleepless energy. The nights were clear and dry, and in the sky or over the white surface of the lake, insects were probably easily seen at any hour by birds accustomed to such gloom as that of my chimney. Still it was wonderful to think of their strength and patience, and of their knowledge of place. Many, if not most, of us poor mortals lose our paths under the simplest conditions, even with the sun smiling down upon us, or the stars writing their ancient guideboards anew for us in the dark heavens, toward which we will not turn for aid. These swifts, however, seem to plow through darkness or light with equal confidence, cleaving the cool wind at the rate of more than a mile a minute, seeing first the pale lake below their chimney's shadow, then the vast peak of Chocorua, framed in its somber spruces, and again some far range of untrodden mountains where fellow swifts still nest in hollow tree trunks, after the ancient practice of their family. What marvelous sense is it which brings them back by day or by night, in sunlight or in storm, straight as thought itself, to home and rest?

I never have met a man who remembered having seen a swift perch. It was formerly supposed that they had no feet, and some people still believe the fable. In building time the birds come spinning through the air like projectiles, and while flying thus, snap small terminal twigs from sycamores and other brittle trees, and carry them back to their chimneys, to be painstakingly glued into their fragile nests. After seeing my swifts use their feet so readily in getting to and from their nest, I shall not be much surprised some day to see a swift alight upon some convenient perch outside his chimney. Nevertheless, so far as is now known, the swifts take no rest even after flying many miles with incredible speed, until their accustomed shelter is regained.

When Saturday came, I felt that it was time to see more of my noisy tenants. In the intervening days something which looked like a happy thought had come to me. Why should I lie supine among the fire irons, gazing up the black chimney hole, when, by judicious use of a few mirrors, I could bring the swifts and their cavern within range of my writing table? Saturday morning the small mirror climbed the flue a second time, and was firmly lashed in position a few inches above the nest. The lashing, of course, was applied to the butt of the fishing rod, at the point where it rested in the fireplace among andirons and tongs. Then a narrow, old-fashioned mirror, in which somebody's great-grandmother may have admired her pretty face in the days of a long-forgotten honeymoon, was gently rested upon the single stick of wood at the back of the fireplace so that its face inclined slightly toward me. Wonderful!—there were the shiny flue, the

nest, the frightened bird perching far up the shaft, and the narrow line of sky above her; and there also was the small glass at the tip of my fishing rod, and in its oval face was an image of the inside of the shallow nest with two fat, featherless, sightless swifts flopping about in it. Nothing could now be easier than to watch the entire process of rearing the infant projectiles from a state of feebleness and imbecility to that marvelous condition of grace, speed, and intelligence at which they would, in the natural course of events, arrive in a few brief days.

My first desire was to ascertain how they were fed. The barn swallows, who by some freak have taken possession of a pewee's nest just under the eaves of my cottage, feed their young with insects which they bring bristling in their beaks. I had expected to see the swifts bring insects to their babies, but my closest scrutiny failed to discover anything in their beaks when they arrived, or when they went upon the nest. Under the new conditions I watched with double care and attention. At first, for nearly an hour, the birds were too much disturbed by the glass and fishing rod to settle upon the nest. They came close to it and chattered, but flew nervously and noisily, as though to frighten away the intruder. After a while they grew quieter, and finally one arrived with food. She came to the nest, mounted its edge, and leaned toward the open-mouthed young. Then she moved violently, and seemed to hang over the infants, to pound them, shake them, and push them back and forth in a singularly rough and unkind way. Seeing all these things by double reflection and in the dim light of the chimney, I could not be certain of details, but all that I saw reminded me of descriptions I had heard and read, of feeding young birds by regurgitation, while nothing that went on looked like the quiet and matter-of-fact process of dropping a fly into a little bird's gaping mouth. It seemed to me that the parent inserted her bill in the young one's throat, and then presumably pumped into it, by the violent motions which she made, a portion of the food previously swallowed by her. After being fed, the young dropped back limp or satisfied into the nest, and were promptly sat upon and hustled into a comfortable and orderly condition. Apparently both birds joined in feeding their offspring, for I saw first one and then the other go through this peculiar process.

Supposing that I should have ample opportunity for several days to watch the feeding, I did not devote myself to its study as faithfully as I should have, had I foreseen the distressing event which was in store for my tenants. On Saturday afternoon a light rain fell. The faithful mother sat upon her nest while multitudes of tiny drops floated down the chimney. They did not fall, but seemed to sail unwillingly through the gloom, held aloft

by the ascending currents of air. Each globule shone with light, and looked almost as white as a snowflake. As they approached the nest few seemed to touch it, but curved away from it in some eddy of the air, and settled down into the depths of darkness below. During the rain both birds remained in the chimney most of the time. Sunday, July 16th, proved to be an unusually warm day, and, what was perhaps of more moment to the swifts, a very dry day, there seeming to be no moisture left in air or vegetation. About noon, while writing at my table, I heard the familiar booming, whistling, and chirping in the chimney, and as I glanced up I saw that one of the birds was coming to the nest and the other just going off up chimney. Suddenly there was a grating sound, a sharp outcry, more booming and fluttering, and I jumped to my feet and knelt before the glass to gain a closer view of the chimney. The nest had vanished. Only a tiny piece of glue adhered to the slight curve in the bricks under which the nest had been attached. The parent bird, with ruffled plumage and rapidly moving head, clung near the spot where her home had been, and seemed to me to be looking with terror far down into that horrible abyss where her young had fallen, and from which they sent back no cry. Taking down the pointed rod, I used the small mirror to search every part of the great chimney cavern which could be reached, but in vain. The nest had gone straight down without touching any fireplace, and had been lost forever in the *débris* and stifling dust at the bottom of the shaft.

During the remainder of the day the birds fluttered back and forth and lamented. They did not go more than two or three inches below the spot where the ill-fated nest had been. At intervals during the night I heard them moving in the chimney, but on Monday they stayed away most of the time, even during a heavy shower which fell late in the afternoon. Toward evening I saw both of them perched near the site of their fallen home, and during that night and on other days and nights the sound of their wings occasionally came to me as a reminder of their vanished happiness. They made no effort to rebuild in my chimney, yet their presence in it seemed to show that they had not begun housekeeping elsewhere. I doubt not that another summer, that love of home which is so closely connected with birds' ability to find a familiar spot by day or by night, even after months of absence, will bring my swifts back to their old flue.

It appears from the altitudes of the highest clouds measured at Upsala, Sweden, Kew, England, and Blue Hill, Mass., that the upper limit of ordinary clouds in temperate latitudes is between thirteen and fifteen kilometres, or nine miles; but it is possible that more numerous measurements may extend it to ten miles.

FROST-FORMS ON ROAN MOUNTAIN.

By Mrs. HELEN R. EDSON.

THIS is the only habitable high mountain peak east of the Pacific ranges. Its altitude, six thousand three hundred and thirteen feet above the sea level, tempered by its latitude, thirty-six degrees, together with its isolation from other mountains of similar height, renders it one of the most favorable places for the observation of atmospheric conditions. The clouds here usually float about level with the summit, though they sometimes rise as much as five hundred feet above it, or sink two

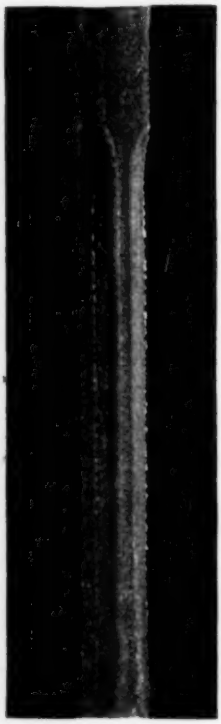

Fig. 1.

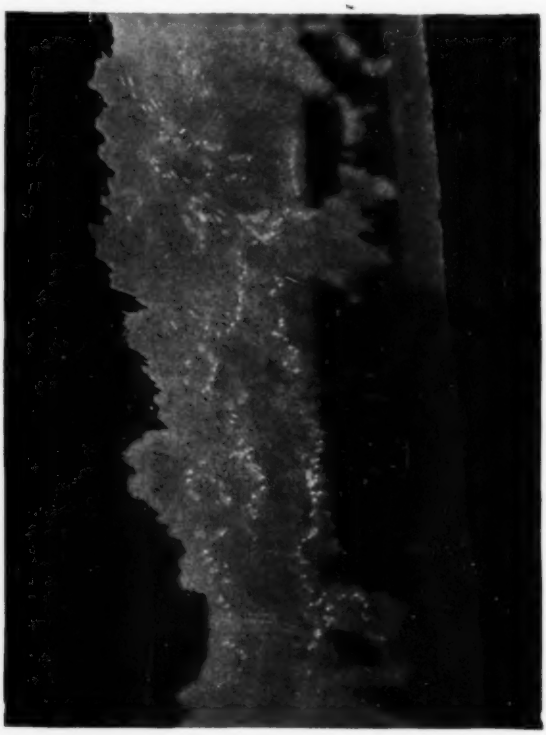

Fig. 2.

thousand feet below; so that it may be said to lie in the track of the clouds.

I regret that I was not better equipped for a thorough study of frost-forms produced by the lateral deposit of the frozen vapor in the clouds during the severe winter of 1892–'93, which I spent upon the summit of Roan Mountain for the sake of an invalid daughter. There was not a hygrometer within reach, hence the amount of moisture in the atmosphere at any given time can not

be stated. The anemometer was frequently clogged by accumulations of frost upon it. Incessant winds and flying snow dust prevented the taking of clear photographs out of doors, and many plates were spoiled by inexperienced handling.

The factors in the production of these frost-forms are the frozen vapor and the wind. Their size, shape, and location are

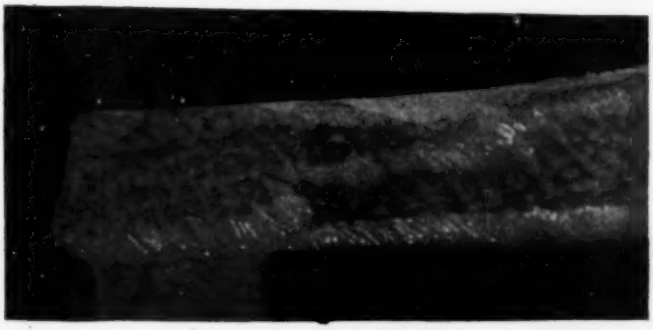

FIG. 3.

controlled by the amount of moisture, the temperature, the direction and velocity of the wind, the shape, size, and situation of the objects on which they are deposited, and the size and nearness of the surrounding objects. The lower the temperature, the denser the cloud, the swifter the wind, and the more perfect the exposure, the more rapid the growth and the more profuse and elaborate the results.

Fig. 1 shows a six-sided wooden pillar with a deposit made in two hours. Wind, about thirty miles an hour; temperature, fifteen degrees below zero. Frost in the form of fir-tips, projecting three quarters of an inch from the corners, and one fourth to one half inch from the spaces intervening. A space two inches square contained twenty-five.

Fig. 2 shows the same pillar a week later, after five days of storm and two of sunshine. Frost-forms now projecting fourteen inches and glazed on outside.

There is no fixed proportion between the size of the base of the deposit and the deposit itself. It is remarkable for cohesive strength, stiffness, and tenacious grip upon its base. In the case of round bodies, such as trees or wires, it clasps but half the circumference, the other half being not even glazed (unless some large object be directly to leeward), and stands out on the windward side of its support, following its curves and angles with precision. Sometimes a tree or a grove of trees may be seen entirely white on one side and green on the other.

Unless there are numerous changes in the direction of the wind during the progress of construction, the first aggregations

of particles have the same general configuration as the finished ornaments hundreds of times as large—six to eight inches wide at the base and projecting twelve to sixteen inches. A slight variation in the direction or velocity of the wind makes them more complex and adds greatly to their beauty; but a change of as much as sixty degrees in the direction wrenches them from their supports. They come away entire, and lie in heaps under the trees like autumn leaves, and may be collected and preserved in a cold, sheltered place until they gradually evaporate.

The process of formation is an interesting study. It is impossible to follow the course of the fine particles of snow dust which make up the most beautiful forms; but at a temperature of twenty-five to thirty degrees above zero the frozen moisture

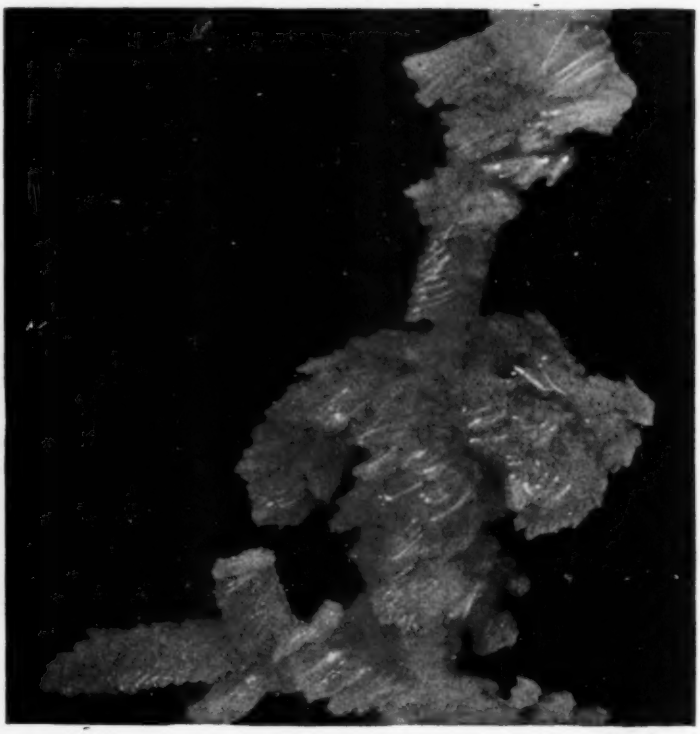

FIG. 4.

comes in minute pellets of ice which may be watched with a good microscope as they strike a chosen spot. The development of the ice-forms is much more rapid than that of the snow-forms; otherwise the processes seem to be identical.

On the edges of flat surfaces, and along the diameters of round bodies, lines of particles are deposited as the wind rushes past the obstruction. Then begins a twofold growth, caused by the direct

application of other particles on the windward side, and by the rebound to the lines already laid of those particles which are driven violently against the surfaces between the lines. On smooth, narrow bodies, as this process is continued, the deposits along the sides or edges soon become so thick and long as to meet in the middle. On rough surfaces new lines and centers of groups are begun on all projections, however slight, and the particles rebound to them from the surrounding surfaces.

Fig. 3, a section of rough board, illustrates this. The deviation from the perpendicular in the frost-forms on the edges is due to the fact that the board was not accurately facing the wind.

There is, of course, a great variety of forms produced in different storms, all wonderful for delicacy of design and perfection of finish such as could not be imitated in any

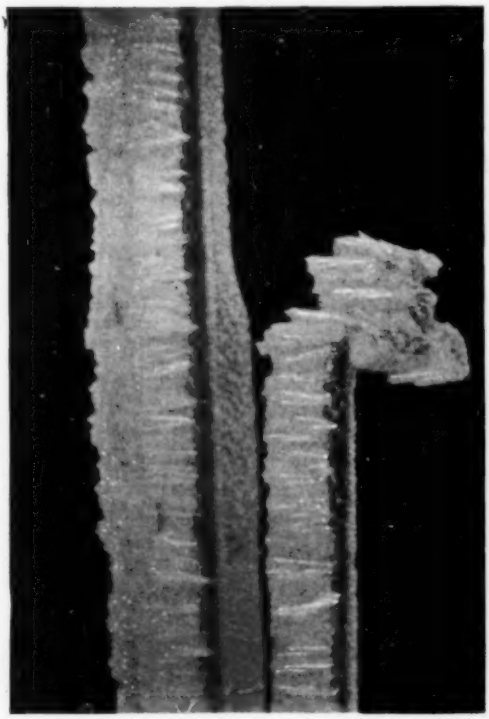

FIG. 5.

FIG. 6.

material. Among them may be shown a branch of balsam fir (*Abies Fraseri*) (Fig. 4) which bears the heavy fringe of the storm of December 28th, when the wind blew at the rate of fifteen to twenty-five miles an hour, and the temperature was fifteen degrees above zero.

Fig. 5, a pillar and standpipe, shows the perfect fir-tip pattern of January 3d. Wind, fifteen to thirty miles an hour; temperature, ten degrees below zero. The lower temperature and swifter wind account mainly for the difference between this form and the preceding one. The leeward sides of pillar and pipe are thinly coated by the rebound of particles from the house wall.

Fig. 6, the accumulation on the tip of a blade of grass, seven eighths of an inch long. This fragment was broken off and brought into the house to show how all the grass was decorated by the storm of January 6th, with wind at forty miles an hour and temperature twenty degrees below zero. It was two inches and three quarters tall and weighed three quarters of an ounce avoirdupois, or more than five thousand times as much as the bit of grass inclosed by it. It was composed of ten large feathers, with the spaces between them filled with smaller ones—no shapeless snow about it. The tips of twigs, ends of fence rails, etc., projecting toward the wind, were all similarly decorated, but on different scales, according to their size and exposure.

Many curious and apparently contradictory effects are produced by the rebound from one surface to another. A post which

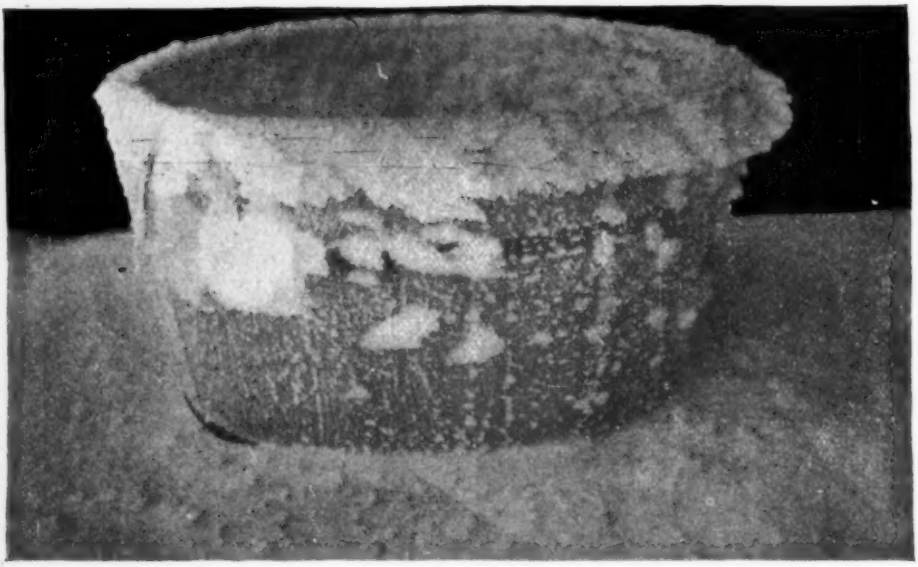

Fig. 7.

stood twenty feet from the house, in a small court inclosed on three sides, had a deposit on the face toward the house equal to that on the windward side, while the other sides were bare and dry.

Fig. 7 shows a wreath of plumes averaging six inches in length, formed altogether upon the leeward side of a tub, by the rebound of the vapor-laden wind from a high wall about three feet distant. It will be seen that the rebound from the tub again has produced a second series of forms around it on the ground, pointing toward the tub.

The most conspicuous and noteworthy example of this resili-

ent force was exhibited at the close of the storm of January 6th to 8th, in a recess where a north wing joins the main hotel building. The speed of the wind varied from forty to sixty miles an hour during those three days, and the temperature was from fifteen to thirty degrees below zero.

Fig. 8 presents a sketch of the outlines. A B is the northwest corner of the main building. three stories high. C is two stories high, and E D one story. F shows the direction of the wind, which varied little. A, B, D, and E had heavy, deep cornices of long, narrow plumes like pampas grass, averaging sixteen inches in length, inclined outward from base to tip at an angle of thirty degrees to the plane of the wall, and lying in a horizontal position. The plumes on A and E pointed north by northwest; those on B, west by northwest; all as directly toward the wind as was allowed by the laws governing their application to the walls and by the angles at which the wind struck the walls. Those on D, being formed by the rebound from the high wall C and the angle C B, pointed east, or toward C, though in all other respects similar to the others. On the weatherboards of A, B, and E the frost-feathers were short and broad. They stood vertically, with their bases on the edges of the boards, each row overlapping the row above, and each row formed by the downward rebound of particles from the thick edge of the board above it. The forms on all the upright corner boards (or facing boards) seemed to have been made later than those on the weatherboards, since they lay horizontally, with their tips pointing toward those on the weatherboards, and at a right angle to them. They must have been made by the rebound from the forms on the weatherboards, as their direction in every instance was exactly opposite to that of the cornice decorations on the same wall. After the first few hours it was impossible to brave the fury of the storm to watch the process of development, which is inferred from the results and the proved rules by which the work is done.

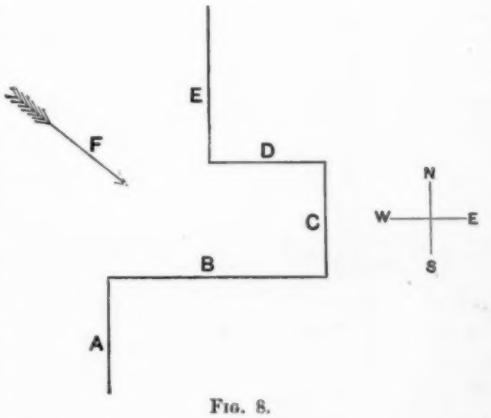

FIG. 8.

The forms on the weatherboards of D hung downward, while those on the opposite wall, B, stood upright. This must have been due to the rotary motion of the wind after it struck the three-story wall B and the two-story wall C, and, whirling down-

ward and upward again from the ground, struck the one-story wall D.

Fig. 9 shows a section of the wall D in the beginning of that storm. Unfortunately, the other negatives of that group were spoiled.

On C the deposits on cornice and weatherboards nearest D partook of the shape and direction of those on D; and the same

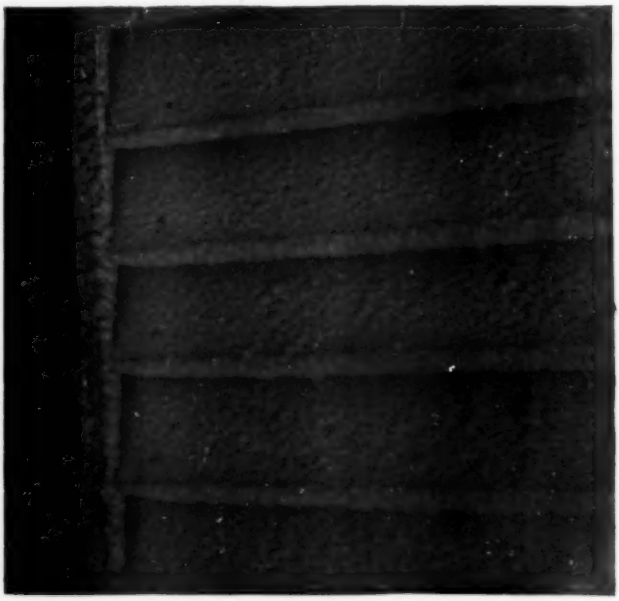

FIG. 9.

was true of those nearest B. In the space intervening, the frost was laid on obliquely, resembling the first course of a heavy lattice. All these walls, as well as all others on the mountain top which faced the west and north, were completely covered, and presented the appearance of exquisitely chiseled marble.

On all flat surfaces, whether curved or rectilinear in outline, when they are suspended vertically, faced to the wind, so that it may blow past all sides unobstructed, the frost-forms lie at an angle of thirty degrees to the surface, with their bases to its edges, and point accurately toward the center.

On a flat surface having a rim that projects as much as half an inch, they are built on the inner edge of the rim, and extend toward the center at a right angle to the rim and parallel to the surface. When the rim is more shallow, their bases are set in the angle where the rim joins the surface, and they stand out from the surface at an angle of more than thirty degrees.

Fig. 10 is the lid of a cream freezer, showing frost-forms point-

ing toward the center and extending parallel to the face of the disk.

On a tumbler, three inches and a quarter in depth and two inches and a quarter in diameter at the top, placed with its mouth to the wind, the result was the same. The frost-forms pointed toward the center and were parallel to the bottom of the tumbler. It might be worth while to find out by experiments how deep and how wide a vessel would be required to cause them to deviate from this rule.

Fig. 11 exhibits an iron pipe elbow, part of the deposit on which was affected by the rebound from the longer curved side as the wind passed through it. If a straight section of pipe be placed so that the wind may pass through it unobstructed, the deposit is made on the windward end, of the same thickness as the metal; and it appears as though that part of the pipe had been

FIG. 10.

cast in the pattern prevailing in that storm, and whitened. The outer and inner longitudinal surfaces of the pipe are left bare and dry.

Very pretty experiments may be made with apples, chairs, wheels, tin cans, feathers, and other objects too numerous to mention.

Fig. 12 is an apple with a faithful imitation of a chrysanthemum on one side. This was made at a low temperature and was white. The most beautiful blossoms were those made of sleet, at a temperature of twenty-five to thirty degrees above zero. They

were sometimes as large as the apples, and always had from twelve to twenty perfectly shaped petals, from one inch to two inches and three quarters long.

It often happens that the clouds clear away and the temperature rises a few degrees while the direction of the wind is still unchanged. Then the outer surfaces of the frost-forms become glazed and the softer filling is blown out. They may be taken off entire, and need no greater care in handling than fine china. They are thin as eggshells and translucent, and under the microscope show long rows of minute cells, separated by delicate filiform partitions. A contrary wind unclasps their hold and the ground is strewn with the curious wreckage. They may be kept for many days in a cold place.

In sheltered places, a little way down on the leeward side of the mountain, the deposits of frozen vapor are similar to the hoarfrost seen in the lowlands, but greatly exaggerated in size and profusion, and are usually in the form of small rosettes, set as thickly as possible upon all surfaces of trees, rocks, or buildings.

The frost on the windows of all unoccupied rooms varies in shape and amount according as the temperature is higher or lower. At fifteen degrees above zero, small fern-shaped figures are made, about a quarter or a half an inch long. At lower temperatures they decrease in size and increase in numbers, until,

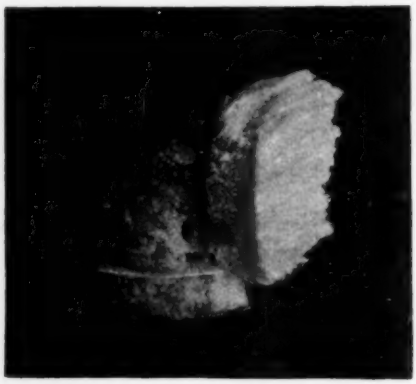

FIG. 11.

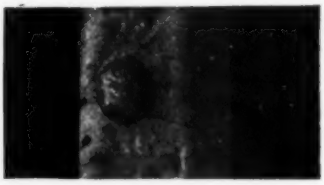

FIG. 12.

at thirty degrees below zero, the panes are quite covered with tiny frost ferns, twenty-five of which have been counted in a space an inch square, every one perfect in outline. Above fifteen degrees above zero the shape changes to something like the *Hypnum* moss.

Fig. 13 represents part of a pane. The temperature fell below fifteen degrees for a short time, allowing the accumulation of a few of the fern-forms, and then rose rapidly to twenty-five degrees, with the result here shown. The moisture condenses upon the windows of inhabited rooms just about as it does everywhere else.

I watched throughout the winter for the stellar and hexagonal snowflakes, but never found them while the clouds enveloped the mountain. The particles of frozen vapor in the clouds resemble finely ground meal. When a cloud rises from fifteen to

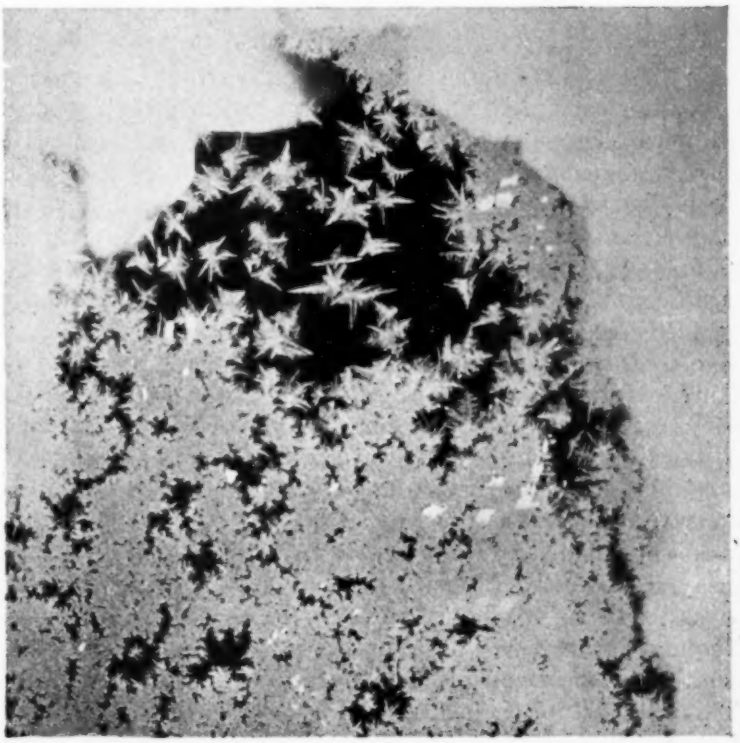

Fig. 13.

twenty feet above any given place, several of these particles (usually six or eight) come down joined together like beads on a pin; when it rises fifty or a hundred feet, the little sticks of globules cross and adhere to each other in falling, and reach the earth in all the complex shapes commonly called snow crystals.

Nothing escapes the ravages of insects, not even books. One of the insect "enemies of books" is the *Lepisma saccharina*, often called the silver fish, which is marked by its luster and its activity. Prof. Westwood once named a minute beetle, which had done much mischief to the cover of a book, *Hypothene mus erudites*. Specimens of books damaged by insects are exhibited in the South Kensington Museum, London. Mr. Zaehnsdorf, a bookbinder, has formed a collection of the book pests which he has met in the exercise of his calling. The Arabs are said to write sometimes the name *Kabikaj*, the name of a genius who presides over insects, on their manuscripts, in order to protect them from the ravages of his subjects.

THE ICE AGE AND ITS WORK.

By ALFRED R. WALLACE, F. R. S.

EROSION OF LAKE BASINS.

III.

LAKES are distributed very unequally over the various parts of the world, and they also differ much in their position in relation to other physical peculiarities of the surface. Most of the great continents have a considerable number of lakes, many of great size, situated on plateaus or in central basins; while the northern parts of Europe and North America are thickly strewn with lakes of various dimensions, some on the plains, others in subalpine valleys, others again high up among the mountains, these latter being of small size and usually called tarns. The three classes of lakes last mentioned occur in the greatest profusion in glaciated districts, while they are almost absent elsewhere; and it was this peculiarity of general distribution, together with the observation that all the valley lakes of Switzerland and of our own country occurred in the track of the old glaciers, and in situations where the erosive power of the ice would tend to form rock-closed basins, that appears to have led the late Sir Andrew Ramsay to formulate his theory of ice-erosion to explain them. He was further greatly influenced by the extreme difficulty or inadequacy of any possible alternative theory—a difficulty which we shall see remains as great now as at the time he wrote.

This question of the origin of the lake basins of the glaciated regions is especially interesting on account of the extreme divergence of opinion that still prevails on the subject. While the general facts of glaciation, the extent and thickness of the old glaciers and ice-sheets, and the work they did in distributing huge erratics many hundred miles from their sources and in covering thousands of square miles of country with thick layers of bowlder clay and drift, are all admitted as beyond dispute, geologists are still divided into two hostile camps when the origin of lake basins is concerned; and the opposing forces seem to be approximately equal. Having for many years given much attention to this problem, which has had for me a kind of fascination, I am convinced that the evidence in favor of glaciation has not been set forth in all its cumulative force, while many of the arguments against it seem to me to be either illogical or beside the point at issue. I have also to adduce certain considerations which have hitherto been overlooked, but which appear to me to afford very strong if not conclusive evidence for erosion as against any alternative theory yet proposed. I shall, therefore, first set forth, as

fully as the space at my command will allow, the general evidence in favor of the ice origin of certain classes of lakes, and the special conditions requisite for the production of lakes by this agency. The objections of the best authorities will then be considered and replied to, and the extreme difficulties of the alternative theories will be pointed out. I shall then describe certain peculiarities, hitherto unnoticed, which clearly point to erosion, as opposed to any form of subsidence and upheaval, in the formation of the lakes in question. Lastly, the special case of the Lake of Geneva will be discussed, as affording a battle ground that will be admitted to be highly favorable to the anti-glacialists, since most of them have adduced it as being entirely beyond the powers of the ancient glaciers to have produced.

THE DIFFERENT KINDS OF LAKES AND THEIR DISTRIBUTION.—To clear the ground at the outset, it may be well to state that the great plateau lakes of various parts of the world have no doubt been formed by some kind of earth movements occurring subsequent to the upheaval and partial denudation of the country. It is universally admitted that existing lakes can not be very ancient, geologically speaking, since they would inevitably be filled up by the sediment carried into them by the streams and by the wind. Our lakes must, therefore, be quite modern features of the earth's surface. A considerable proportion of these plateau lakes are in regions of little rainfall, and many of them have no outlet. The latter circumstance is a consequence of the former, since it indicates that evaporation balances the inflow. This would have favored the formation of such lakes, since it would have prevented the overflow of the water from the slight hollow first formed, and the cutting of an outlet gorge which would empty the incipient lake. Captain Dutton, in his account of the geology of the Grand Cañon district, lays stress on this fact, "that the elevation of a platform across the track of a river rarely diverts it from its course, for the stream saws its bed into the rocks as fast as the obstacle rises." Scanty rainfall and great evaporation seem therefore to be almost essential to the formation of the larger plateau lakes. Rarely, such lakes may have been formed in comparatively well-watered districts, but the earth movements must in these cases have been exceptionally rapid and extensive, and they are accordingly found most often in countries subject to volcanic disturbances. Such are the lakes of southern Italy, of Macedonia, of Asia Minor, and perhaps those of Central Africa.

Quite distinct from these are the subalpine lakes of those mountain groups which have been subject to extreme glaciation. These are characteristically valley lakes, occurring in the lower portions of the valleys which have been the beds of enormous glaciers, their frequency, their size, and their depth bearing some

relation to the form and slope of the valleys and the intensity of the glaciation to which they have been subject. In our own country we have in Wales a small number of valley lakes; in the Lake District, where the ice-sheet can be proved to have been much thicker and to have lasted longer, we have more numerous, larger, and deeper lakes; and in Scotland, still more severely glaciated, the lakes are yet more numerous, many of those in the west opening out to the sea and forming the lochs and sounds of the western Highlands. Coming to Switzerland, which, as we have seen, bears indications of glaciation on a most gigantic scale, we find a grand series of valley lakes both on the north and south, situated for the most part in the tracks of those enormous glaciers whose former existence and great development are clearly proved by the vast moraines of northern Italy and the traveled blocks of Switzerland and France. In Scandinavia, where the Ice age reigned longest and with greatest power, lakes abound in almost all the valleys of the eastern slope, while on the west the fiords or submerged lakes are equally characteristic.

In North America, to the south of the St. Lawrence River and of Lakes Ontario and Erie, there are numbers of true valley lakes, as there are also in Canada, besides innumerable others scattered over the open country, especially in the north, where the ice-sheet must have been thickest and have lingered longest. And in the southern hemisphere we have, in New Zealand, a reproduction of these phenomena—a grand mountain range with existing glaciers, indications that these glaciers were recently much more extensive, a series of fine valley lakes forming a true lake district, rivaling that of Switzerland in extent and beauty, with fiords on the southwest coast comparable with those of Norway.

Besides these valley lakes there are two other kinds of lakes always found in strongly glaciated regions. These are Alpine tarns—small lakes occurring at high elevations and very often at the heads of valleys under lofty precipices; and small or large plateau or low-level lakes which occur literally by thousands in northern Canada, in Sweden, Finland, Lapland, and northwestern Russia. The valley lakes and the Alpine tarns are admitted by all geologists to be mostly true rock basins, while the plateau and low-country lakes are many of them hollows in the drift with which much of the country is covered, though rock basins are also not infrequent.

Here, then, we see a remarkable association of lakes of various kinds with highly glaciated regions. The question is whether there is any relation of cause and effect in the association; and to determine this we must take a rapid survey of other mountain regions where indications of ice action are comparatively slight or altogether wanting, and see whether similar lakes

occur there also. The comparison will, I think, prove very instructive.

Spain and Portugal are pre-eminently mountainous countries, there being a succession of distinct ranges and isolated mountain groups from east to west and from north to south; yet there is not a single valley lake in the whole peninsula, and but very few mountain tarns. Sardinia and Corsica are wholly mountainous, but they do not appear to possess a single valley lake. Nor does the whole range of the Apennines, though there are many large plateau lakes in southern Italy. Farther south we have the lofty Atlas Mountains, but giving rise to no subalpine valley lakes. The innumerable mountains and valleys of Asia Minor have no lakes but those of the plateaus; neither has the grand range of the Lebanon, a hundred miles long, and giving rise to an abundance of rivers. Turning to the peninsula of India, we have the ranges of the Ghauts, eight hundred miles long, the mountain mass of the Neilgherries and that of Ceylon, all without such lakes as we are seeking, though Ceylon has a few plateau lakes in the north. The same phenomenon meets us in South Africa and Madagascar—abundance of mountains and rivers, but no valley lakes. In Australia, again, the whole great range of mountains from the uplands of Victoria, through New South Wales and Queensland to the peninsula of Cape York, has not a single true valley lake. Turning now to the New World, we find no valley lakes in the southern Alleghanies, while the grand mountains of Mexico and Central America have a few plateau lakes, but none of the class we are seeking. The extremely mountainous islands of the West Indies—Cuba, Hayti, and Jamaica—are equally deficient. In South America we have on the east the two great mountain systems of Guiana and Brazil, furrowed with valleys and rich in mountain streams, but none of these are adorned with lakes. And, lastly, the grand ranges of the equatorial Andes, for ten degrees on each side of the equator, produce only a few small lakes on the high plateaus, and a few in the great lowland river plains—probably the sites of old river channels—but no valley lakes in any way comparable with those of Switzerland or even of our own insignificant mountains.

Having thus roughly surveyed the chief mountain regions of the whole world, we find that true subalpine valley lakes—that is, lakes in the lower parts of the valleys descending from mountain ranges or groups, filling up those valleys for a considerable distance, usually very deep, and situated in true rock basins—that such lakes as these are absolutely unknown anywhere but in those mountain regions which independent evidence shows to have been subject to enormous and long-continued glaciation. No writer that I am acquainted with has laid sufficient stress on this really

marvelous fact of lake distribution. Prof. Bonney passes it by with the remark that there is a perfect gradation of lakes from the smallest tarns to those of North America and Central Africa; and Mr. Douglas Freshfield says that wherever on the surface of our globe there are heights there must be hollows; and other writers think that lakes are general results of the process of mountain-making. But none of these writers have apparently even noticed the fact that glacier valley lakes have a distinctive character which separates them broadly from the lakes of all non-glaciated countries, and that they are totally absent from such countries.

But besides the mountains which possess true valley lakes, there are a number of ranges which have been glaciated yet do not possess them, and this absence of lakes has been used as an argument against the connection of valley lakes with glaciation. A little examination, however, shows us that these cases greatly strengthen our argument. Comparatively large and deep valley lakes are the result of excessive glaciation, which has occurred only when conditions of latitude, altitude, and moisture combined to produce it. In regions where glaciation was of diminished intensity, from whatever causes, valley lakes diminish in size and number, till at last only tarns are found in moderately glaciated districts. Thus, the Pyrenees were far less severely glaciated than the Alps; they consequently possess no large valley lakes, but numerous small high lakes and tarns. As we go eastward in the Alps, the diminished rain and snowfall led to less severe glaciation, and we find the valley lakes diminish in size and numbers till far east we have only tarns. The Carpathians have no valley lakes, but many tarns. The Caucasus has no lakes and very few tarns, and this may be partly due to the steepness of the valleys, a feature which is, as we shall see, unfavorable to lake formation. In the South Island of New Zealand the lakes are small in the north, but increase in size and number as we go south where the glaciation was more intense. These numerous facts, derived from a survey of the chief mountains of the world, are amply sufficient to show that there must be *some* causal connection between glaciation and these special types of lakes. What the connection is we shall inquire later on.

THE CONDITIONS THAT FAVOR THE PRODUCTION OF LAKES BY ICE EROSION.—Those who oppose the production of lake basins by ice erosion often argue as if the size of the glacier was the only factor and urge that, because there are no lake basins in one valley where large glaciers have been at work, those which exist in another valley where the glaciers were no larger, could not have been produced by them. But this by no means follows, because the production of a lake basin depends on a combination of

favorable conditions. In the first place it is evident that ice erosion to some extent must have taken place along the whole length of the glacier's course, and that in many cases the result might be simply to deepen the valley all along, not quite equally, perhaps, but with no such extreme differences as to produce a lake basin. This would especially be the case if a valley had a considerable downward slope, and was not very unequal in width or in the nature of the rocks forming its floor. The first essential to lake erosion is, therefore, a differential action, caused locally either by increased thickness of the ice, a more open and level valley floor, or a more easily eroded rock, or by any combination of these.

If we look at the valley lakes of our own country and of Switzerland, the first thing that strikes us is their great length and their situation, usually at the lower end of the valley where it emerges from the higher mountains into comparatively low country. Windermere is over ten miles long, Ullswater nearly eight miles, and the larger lakes of Switzerland and North Italy are very much longer. The first essential condition, therefore, was a valley the lower part of which was already nearly level for several miles, and with a considerable width to the base of the mountain slopes. In the non-glaciated districts of our own country, the Dart and the Tamar are examples of rivers which have cut their valleys down nearly to sea-level while still among the hills; and in South Wales the Wye, the Usk, and the Severn have a similar character.

It must always be remembered that glacial erosion is produced by the tremendous vertical pressure of the ice, by its lower strata being thickly loaded with hard rocks frozen into its mass, and by its slow but continuous motion. In the lower part of its course a glacier would be most charged with rocky *débris* in its under strata, since not only would it have been continually breaking off and absorbing, as it were, fresh material during every mile of its onward course, but more and more of its superficial moraines would be ingulfed by crevasses or *moulins*, and be added to the grinding material below. That this was so is proved by the great quantity of stones and grit in the "till," which is thought by Prof. James Geikie to consist, on the average, of as much stony matter as clay, sometimes one material preponderating, sometimes the other. The same thing is indicated by the enormous amount of *débris* often found on the lower parts of large glaciers. The end of the great Tasman Glacier in New Zealand is thus completely hidden for five miles and most of the other glaciers descending from Mount Cook have their extremities similarly buried in *débris*. Dr. Diener found the Milam Glacier in the central Himalayas completely covered with moraine rubbish; and Mr. W. M. Conway states that the lowest twenty miles of the

Hispar Glacier (forty miles long) are "entirely covered with a mantle of moraine." If these glaciers extended to over a hundred miles long, as did the Rhone Glacier when it reached the Lake of Geneva, much of this *débris* would probably have found its way to the bottom, and thus supply the necessary grinding material and the abundant stones of the "till" found everywhere in the tracks of the old glaciers.

Again, although ice is viscous and can slowly change its shape to almost any extent, yet it takes a considerable time to adapt itself to continually changing outlines of the valley bottom. Hence, where great inequalities occur portions of the rocky floor might be bridged over for a considerable space, and where a valley had a narrow V-shaped bottom the subglacial stream might eat away so much of the ice that the glacier might rest wholly on the lateral slopes, and hardly touch the bottom at all. On a tolerably wide and level valley bottom, however, the ice would press with its fullest intensity, and its armature of densely packed stones and rock fragments would groove and grind the rocky floor over every foot of its surface, and with a rate of motion perhaps greater than that of the existing Greenland and Alaskan glaciers, owing to the more southern latitude and therefore higher mean temperature of the soil and the ice. At the same time subglacial streams, forced onward under great hydrostatic pressure, would insinuate themselves into every vacant groove and furrow as each graving tool successively passed on and the one behind it took a slightly different position; and thus the glacial mud, the product of the erosion, would be continually washed away, finally escaping at the lower extremity of the glacier, or in some cases getting embayed in rocky hollows where it might remain permanently as masses of clayey "till," packed with stones and compressed by the weight of the ice to the hardness of rock itself. The continual lubrication of the whole valley floor by water forced onward under pressure, together with the ever-changing form of the under surface of the glacier as it slowly molded itself to the varying contours of the rocks beneath, would greatly facilitate the onward motion. Owing to these changes of form and the great upward pressure of the water in all the hollows to which it gained access, it seems probable that at any one time not more than half the entire bottom surface of the glacier would be in actual contact with the rock, thus greatly reducing the friction; while, as the process of erosion went on, the rock surfaces would become continually smoother and the inequalities less pronounced, so that even when a rock basin had been ground out to a considerable depth the onward motion might be almost as great as at the beginning of the process.

If, now, we consider that the erosion I have attempted to describe

was going on during a large part of the Glacial period, under a weight of ice varying from one to three or four thousand feet in thickness; that the huge grinding tool was at work day and night, winter and summer, century after century, for whatever number of thousands of years we give to the Glacial period; that, as innumerable other facts prove, the ice moved irresistibly over hill and dale, and up slopes far steeper than any formed by the upward slopes of the bottom of our deepest lakes, what is there of impossible, or even of improbable, in the belief that lake basins were produced by such differential erosion? To the ordinary observer it seems impossible that a mountain valley, half a mile wide and bounded by rocky slopes and precipices two or three thousand feet high, can have been formed without any "convulsion of Nature," but merely by the natural agencies he sees still in action—rain and frost, sun and wind—and that the small, rock-encumbered stream now flowing along its bottom can have carried away the whole of the cubic miles of solid rock that once filled up the valley. But the geologist knows that these apparently insignificant forces *have* done the work, through their continuous action always in one direction for thousands or even for millions of years; and, therefore, having before him so many proofs of the eroding power of ice, in planed and rounded rocks, and in the grooves and furrows which are the latest marks left by the ice tool, and bearing in mind the long duration and possibly recurrent phases of the Ice age—to be measured certainly by tens, perhaps by hundreds of thousands of years—he can have little difficulty in accepting the erosion of lake basins as the most satisfactory explanation of their origin.

Objections of Modern Writers considered.—Prof. Bonney and many other writers ask, why lakes are so few though all the chief valleys of the Alps were filled with ice; and why, for instance, there is no great lake in the Dora Baltea Valley, whose glacier produced the great moraines of Ivrea opposite its outlet into the plains of Italy, and which form a chain of hills fifteen miles long and fifteen hundred feet high. The answer, in the case of the Dora Baltea, is not difficult, since it almost certainly has had a series of lake basins at Aosta, Verrex, and other places where the broad, level valley is now filled with alluvial gravel. But the more important point is the extreme narrowness of the lower part of the valley above Donnas and again near its entrance into the valley of the Po. The effect of this would be that the great glacier, probably two thousand feet thick or more, would move rapidly in its upper layers, carrying out its load of stones and *débris* to form the terminal moraine, while the lower strata, choked in the defiles, would move very slowly. And once out in the open valley of the Po, then a great inlet of the warm Medi-

terranean Sea, the ice would rapidly melt away in the water and in the warm, moist atmosphere, and therefore have no tendency to erode a lake basin.

The Lake of Lugano, with its curious radiating arms, is said to be another difficulty. But each of these arms is the outlet of a valley or series of valleys, which were no doubt reduced to nearly level plains by subaërial denudation before the ice began its work. The basin of these valleys comprises about two hundred square miles and the watershed to the north is moderately high; but there can be no doubt that a large overflow from the Como Glacier poured into it; and the difficulty seems to me to be purely imaginary if we simply recognize the fact that an essential preliminary to lake erosion is a pre-existing nearly level valley bottom.

Another difficulty is said to be the frequent presence of islands in the lakes; but here again the answer is easy. The islands, always ground down to *roches moutonnées*, were craggy hills in the pre-existing valleys, and such hills existed because they had for ages resisted the subaërial denudation which had hollowed out the valleys. The same characters of density or toughness that enabled them to resist ordinary denudation, enabled them also, to some extent, to resist destruction by ice erosion; just as the character of the rocks which enabled ordinary denudation to bring them down to a nearly level surface in the valley bottom, also facilitated the ice erosion which converted the level valley floor into a rock basin and, after the ice left it, into a lake.

Every writer brings forward the well-known fact that the ends of glaciers pass over beds of gravel or moraine matter, without destroying or even disturbing it. But there is no reason why they should do more than compress such beds of loose material and roughly level their surfaces. It is the old delusion of a glacier acting like a scoop or plow that leads to the idea that if it can erode rock slowly it must altogether demolish gravel or bowlder clay. But if we turn to the description I have given of how a glacier erodes a rock basin and apply this to its passage over a bed of gravel or bowlder clay, we shall see that in the latter case the erosion would be much more difficult, because each ice-imbedded stone or rock would press into the yielding material, which would close up instantly behind it under pressure of the ice and thus leave no result. Where the subglacial water accumulated, channels would be cut in the gravel or clay, but elsewhere there would probably be no erosion at all. Some writers maintain that the lakes were all filled up with alluvium previous to the Glacial epoch, and that the ice cleared out this incoherent matter; but it is almost certain that no such clearance would have taken place, because the glacier would pass over such a sur-

face, the stones temporarily furrowing it, while the subglacial water would cut for itself one or more deep channels, and there would thus be no water under pressure acting over the whole surface of the basin, which must be so great an aid to erosion in solid rock.

These considerations apply to the equally common objection, that the great masses of bowlder clay left behind by the ice sheet, and over which it must have passed, prove that it could have had little eroding power. The product of the erosion of irregular rock surfaces in an undulating tract of country, where not carried away by water, would necessarily, by the pressure of the ice, be forced into the more or less sheltered or landlocked hollows, thus tending to equalize the surface contours and facilitate the onward motion of the ice. In such hollows it would be pressed and compacted by the weight of the ice, but would be neither eroded nor forced away until, by the continued process of rock erosion, it became exposed to unequal lateral pressure, when it would be gradually removed to some other sheltered hollow, perhaps to again undergo the same process of removal at a later period, and finally rest in the positions in which we find it. During the later stages of the Ice age when, notwithstanding the onward motion of the middle portions of the glacier, the lower portion was melting away both above and below, and the terminal ice cliff was permanently retreating, almost the whole of the eroded matter, except what was carried away by the subglacial torrents, would remain behind; and it is this final product of glacial erosion that forms the huge deposits of bowlder clay which encumber the surface of the lowlands in most highly glaciated countries. When, however, the moving ice changed its direction, as it often did, during the varying phases of the Ice age, it sometimes acted most energetically in crushing, dragging, and contorting both the bowlder clay and other superficial beds, often causing the wildest confusion in the deposits and sometimes imbedding huge sheets of Tertiary strata or chalk in the midst of the bowlder clay. But this is a very different mode of action from that by which hard rocks are ground down or lake basins eroded.

In reply to the continual assertions of Prof. Bonney, and of most of the Alpine explorers, that the action of glaciers is entirely superficial, and that they actually preserve the surfaces they cover from denudation, a few facts may be here given. From a large number of gaugings by Dollfus-Ausset, Dr. Penck has calculated that the solid matter in the torrent which issues from the Aar Glacier annually amounts to six hundred and thirty-eight cubic metres for each square kilometre of the surface of the glacier, a quantity sufficient to lower the bed of the glacier one metre in sixteen hundred and sixty-six years, or one foot in five hundred and

five years; and the same writers calculate that the same amount of erosion in a valley by water alone would require two and a half times as long.* Other writers have made estimates less favorable to ice as an agent of erosion; but even if the amount annually be but small, the cumulative effect was undoubtedly very great in the case of the enormous glaciers of the Ice age. The very wide areas covered with bowlder clay and drift in North America, and its great average depth, have already been referred to in my previous article (Popular Science Monthly, April, 1894, p. 782); but a still more striking estimate has been made of the amount of rock *débris* in northern Europe which can be traced to Scandinavia. Dr. Amund Helland states that about eight hundred thousand square miles are covered with such drift to an average depth of one hundred and fifty feet, of which about one hundred feet are of Scandinavian origin, the remainder being local. The area of Scandinavia and Finland, from which this *débris* has been derived, is very much less than the area over which it is distributed, so that to produce it an amount equal to an average thickness of two hundred and fifty-five feet must have been removed from those countries. To this must be added the amount which has gone into the Baltic and North Seas, and also that which has been carried away by rain and rivers since the Ice age passed away, and yet further, the enormous amount that still remains on the lowlands of Scandinavia, and we shall then arrive at an amount probably twice as great as the above estimate, that is, something like five hundred feet as the average amount of ice erosion of Scandinavia during the Glacial period.† Now, unless this estimate is wildly and extravagantly erroneous—and Prof. Geikie adopts it as *prima facie* not extravagant—we have an amount of ice erosion so enormous as to put completely out of court all the allegations of those who attempt to minimize it as a mere smoothing off of sharp angles and rugged surfaces. I am not aware that Prof. Bonney denies the Scandinavian origin of the greater part of the northern drift, and unless he can show that its quantity is something like a fiftieth part only of the estimate of Dr. Helland, I can not understand how he can still maintain that the glaciers and ice-sheets of the Ice age were agents of abrasion, not of erosion, and that they were therefore impotent to grind away the comparatively small amount of rock removed, under the most favorable conditions, from the basins of the valley lakes whose origin we are discussing.—*Fortnightly Review.*

[*To be continued.*]

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* Falsan, La Période Glaciaire, p. 90.

† Fragments of Earth Lore, by James Geikie, F. R. S., 1893, p. 167.

CAUSE AND EFFECT IN EDUCATION.

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I DO not know when the intellectual life is born. If we consult our own very different and individual experiences we would reach a variety of answers. But I shall at least express the experience of a large body of people in saying that this intellectual birth begins when for the first time we apprehend the principle of causation.

In any age there are but few who have attained the intellectual life. The vast majority of the race are still absorbed with the vegetative and animal functions of life. One would say that the birth of the spirit is not yet. Even among those called enlightened the major part merely assent to the principle of causation. They can not be said to apprehend it as an experience of their own intelligence. If you propound the principle to average men and women they will unhesitatingly agree with you. It takes no great cleverness to see that a denial would mean an impossible contradiction. In the sequence of events, causes are followed by adequate and commensurate effects; back of all effects are adequate and commensurate causes. This does very well as an abstract sentiment. But in the next comment which these good people make upon human affairs, it is more than probable that their denial of causation will be quite as direct and explicit as if expressed in so many words. And this is notably the case if the comment be upon those affairs which involve long-standing traditions, as when the talk turns upon political or social or religious issues.

The difficulty of being consistent is a great difficulty. The ability to be consistent is a proper test of intellectual progress. A great advance has been made when the beliefs in one department of thought are not entirely contradicted and neutralized by the beliefs in another department; when even a small residue of positive philosophy remains; when our science does not contradict our religion, and our religion our politics, and our politics our sociology.

How shall one attain even a moderate degree of reason? It is a large task to make the beliefs in any one bundle harmonize. It is a still greater task to make the bundles themselves harmonize with one another. In the autobiography of John Stuart Mill we have the record of such an attempt, and I know of no book in the language, which so stimulates one's desire to undertake a similar task.

Turning now from the workers to their work, the same prin-

ciple will serve as an adequate test of progress. Any branch of knowledge becomes a science only when the relation between cause and effect is rigidly established, and the capricious and accidental are as rigidly eliminated. Comte found his test of science in the power of prediction. There is no science, unless under certain given conditions we can say precisely what will happen. But this, I take it, is only another way of saying the same thing: we can predict only when we have perceived the causal relations.

The most common affairs of life have not yet been reduced in practice to a science. Bread-making, for example, is still a black art. You put flour and water and yeast and salt and lard together, and do certain things to it, and then trust to the gods to make it into bread. Sometimes they do and sometimes they don't. Sometimes you have good bread and more often you don't. Yet I once met a man, an ex-college professor, who said that he always had good bread. His recipe was simple: he made the conditions invariable and the results were likewise invariable. We have all heard of the lady who, when her servant was out, put wood and paper and coal together, applied a match, and then went upstairs and prayed that she might have a fire.

Practically we do not disapprove of this condition of affairs. For the most part, it amuses us.

But the less domestic sciences afford better illustrations of the realization of the principle. In the hands of Kepler, for instance, astronomy failed to be a science. With wonderful skill he applied his knowledge of conic sections to the motions of the planets. Yet he could offer no better explanation of these motions than the suggestion that each planet was the chariot of an indwelling, guiding spirit. We could predict nothing of these imaginary charioteers, for the laws which might be presumed to govern them were quite beyond the limits of investigation. But with the introduction of the conception of universal gravitation, the study of astronomy took rank as a recognized science, and its observed phenomena were reducible to an orderly sequence of cause and effect. It is true that gravitation itself remains as profound a mystery as the charioteers of Kepler, and in substituting the one for the other we have not explained the universe. But we never hoped to do that. The superiority of gravitation lies in this, that it is the cause of uniform and measurable effects. Under Kepler's conception of things, the perturbations of Uranus might be ascribed to a little caprice on the part of the charioteer. Under Newton's conception such a disposition of the irregularities would be impossible. They could result only from the attraction of a definite amount of matter acting at a definite distance. When Adams and Leverrier had completed their calculations, Dr. Galle

knew exactly where to point his great telescope, and, as we all know, it pointed to Neptune.

It was the same with geology. Sir Charles Lyell substituted for the unimaginable cataclysms of the older geologists the slow and simple operations of Nature's present forces. It was his work which changed geology from a wild dream into an accurate science, and to-day we hold this principle of causation as the check and test of all geological speculations.

The science of chemistry was born when the principle of the conservation of matter became established, and men stood face to face with the necessary relation between cause and effect; when they realized their own inability to bring matter out of nothingness, or to make it pass into nothingness again. Similarly, physics, as a science, came only with the recognition of the principles of the conservation of energy and the correlation of forces. It is difficult for us, standing on the vantage ground of the present, to realize into what an abyss we should suddenly plunge if we lost sight for one moment of these gains and passed into a world of thought in which energy came and went and matter appeared and disappeared. It would practically be a world of insanities.

Almost in our own generation we have seen the birth of the science of biology, and we all remember very vividly the bitter pain of its birth. As a branch of study, it has existed from the very earliest days when man first began to observe animated Nature; but it remained a body of isolated facts until the work of Darwin and Wallace established the causal relations involved in evolution, and suggested the mode by which this process of unfolding had been brought about.

It would be very easy to enlarge these illustrations in what we call the "natural" sciences, but it is hardly necessary. The point is probably established.

In those branches of inquiry which have to do with human rather than with purely physical activities, we shall find precisely the same thing; but in this case their history is so complex that the recognition of the principle of causation, and its application to human affairs, have been correspondingly slower. Even now it is far from complete. Nevertheless, in this study of the human spirit, we have all along been blindly trying to establish the principle of cause and effect. In the half-science which has grown out of this attempt, the failure has come, not from a wrong end in mind—and this is to be particularly noted—but rather from the establishment of fictitious causal relationships. In the complex operations of the human spirit we have observed definite results; we have sought for causes; we have not been wise enough to find them; but we have found something which we mistook for causes, and so we have built up a system founded on false re-

lationships. The mistake is difficult to rectify. These imaginary causes must first be swept away. The true science comes only when the true and adequate cause is discovered.

We are witnessing to-day the rehabilitation of the sciences of the human spirit. In all of them the reforming process is the same. It is the mending of the old mistake; the getting rid of the fictitious causations, and the search for the true ones. Thus, for example, the fertile thought in modern sociology is the growing recognition of the fact that national characteristics are the direct outgrowth of the material conditions surrounding the nation—the climate, the soil, the food. The evil of intemperance is being met and vanquished on the same ground, not by prohibitions and pledges, but by the substitution of such a rational diet and such rational life conditions that an exhausted physical system will no longer crave the false stimulus of intoxicants. If a young man drinks to excess we no longer put the blame upon the devil, although in giving up this cause we have certainly dispensed with a great convenience. We put the blame nearer home. The careful housekeeper, overbusy with much scrubbing, has had something to do with it, if in her eager pursuit of dust she has forgotten to provide wholesome, nutritious food for the vigorous, healthy organisms committed to her charge. The home conditions have had something to do with it if they have offered attractions so meager as to be quite outweighed by the anæsthesia of drunkenness.

This modern search after true causation is merciless in its operation. It is a two-edged sword. It is tracing home the source of social distempers to men and women who have hitherto been complacently patting themselves upon the back and putting the blame upon the world, the devil, God, Providence—in a word, upon anything rather than upon their own ignorance.

Among the many activities concerning themselves with the welfare of the human spirit, there is none more complex, more difficult, or more important than that activity which we sum up under the name of education; but the history of its growth is much the same history as that of the sciences, "natural" and "human," which we have just been sketching. If it is to become a science, it is to become one by precisely the same process as these have done—that is to say, by the establishment within itself of true causal relations.

In all of this, one is but the chronicler of the obvious, and says nothing that is new. But probably the verities are mostly old. It is only their restatement that is new. Let us be honest. Let us acknowledge that what we most need is, not so much any fresh accession of truth, as a more sincere and persistent effort to live up to such measure of it as we have.

And yet this very obvious thing has not been done. One can not honestly say that the education of to-day rests upon a scientific basis. It seems to us absurd now that Kepler should have referred the planetary motions to an indwelling will. But we are doing things even more absurd in the name of education. We observe tendencies in children: we refer them to false causes. We desire a certain development: we set in motion the wrong machinery. In a word, as scientists we are causationists; as educators we are not.

Now, what is to be done about it? Modern educators are for the most part sincere, enthusiastic, devoted. Even to those who teach simply for the salary, there must come occasionally an altruistic thrill. Why then do we fail so dismally? Why are we all so blind?

It is easier to ask questions than to answer them; to declare one's self a sinner than to become a saint. But the world is old. It has met many sorrows. We ought from these to be able to learn some lessons. We ought to be able to reach some fertile thought capable of transforming education into a science.

Few problems have had greater play of thought about them than this very problem of education, and it has been thought of a high character. The various lines which this thought has taken are to be found in the histories of education. It is noticeable in glancing over this curious history that all lines converge in this one point, that each system of education which they represent is the somewhat retarded reflection of the *Zeitgeist*—the belated product of the great time-spirit of the age in which they happened to be born. Resting, as education does, upon all the other sciences, it is inevitable that its fruition should follow theirs. With religion and ethics and sociology and biology in a state of incoherence and empiricism, it was manifestly impossible for education to be rational. It was first necessary that the foundation sciences should be reduced to order, and the sequence of cause and effect established within their own borders. This has been done in part. It is the peculiar glory of these closing years of the nineteenth century that they have witnessed a unification of knowledge such as previous ages had not the power even to dream of. These many sciences upon which education rests have been shown to be but so many manifestations of one science, and the phenomena which they study but the operations of one law. And this law expresses the orderly sequence of the universe, the inviolable following of cause and effect, the exclusion of exterior, unmeasurable agencies, the uniform unfolding of the present out of the past—in a word, it is the great law of evolution. The system of education which is the proper flower and fruit of this

accumulated science is clearly a system which proceeds upon this universal principle of development.

We have said that the reflection of the time-spirit which education represents is always and necessarily a somewhat retarded image. It follows the time-spirit. It can not precede it. But were this all, the problem of education would be vastly easier than at present. Fallen as we are upon a scientific age, it would be a comfort to believe that the image of it shown in education would surely conform to it, however slowly. But unfortunately the plate upon which this reflection is thrown is far from free. It bears already the deep impressions of many previous images. At any moment our education reflects not only the living *Zeitgeist*, but also, and even more clearly, the dead standards of a long past. It is seldom that a man arises among us who has sufficiently clear vision to distinguish these several images and apply the upper one to the needs of childhood. It is comparatively easy to refute a sophistry with a new face. It is tremendously difficult to escape the power of a sophistry to which you have been born, and in the presence of whose illogic you have always lived. It takes genius to escape.

But suppose now for one brief moment that we could apply a sponge to this complex plate of ours—not from the front, for that would remove the image we most wish to preserve; but from the back, removing image after image until we came to the last and uppermost—what do you think we should remove, and what let stand, in our current education? I think we should erase much and leave but little. Let us see.

The human infant is a much less complex thing than we are wont to think. It is plastic and general; for the most part a mere bundle of possibilities. And we stand to it in the relation of Fate or Destiny. We have given to us a tiny organism with little individual will or intelligence. The influences to which we subject this organism constitute the educative process.

There are two elements to be considered. First of all, there is wrapped up in this tiny ball of organized matter an inherent tendency more inexorable than the predestination taught by Calvin. We call it heredity. It is the gift, for good or ill, of fathers and great-grandfathers, of mothers and great-grandmothers, for many generations back. The fairy godmothers who come in the story book to every child's christening represent a scientific fact. The talents they bestow, the fatal limitations they inflict, are not by chance. They are the qualities of ancestry.

A system of education neglecting this element of heredity neglects a determining cause, and is fundamentally unscientific. But it is an element largely beyond the control of the teacher. All he can do is to develop these germs, or discourage them, as

heredity seems good or bad. Even in this very moderate function he blunders, for the most part, terribly.

The second element is the one with which we have practically to deal. It includes all post-natal influences. In science we call it environment.

It is a long-standing debate as to which of these elements is the stronger. We need not enter the controversy. The balance of present evidence seems to support that view of the matter which gives the greater influence to environment. In this lies the hope of the educator. We mean to get the best of the dead great-grandmother. Mr. Fiske has pointed out that in the increased helplessness of the human infant, in its greater freedom from inborn instincts, in the lengthening days of the plastic period of infancy are to be found the possibilities of a far greater individual advance.

This, then, is the problem set before us as educators—so to shape these influences that the developing human spirit may approach perfection. It is not a new problem. It was before the Greeks. It was before the men of the middle ages. It has been constantly before our own people. But it has never been very satisfactorily solved.

The extent of our failure can be better realized when we remember that nearly all educational reforms have been forced upon the schools from without. They originated with men and women who were so fortunate as to escape the pedagogical blight. When we remember further that the men of mark in the great world of action and creative thought have either been educated in an irregular fashion, or, if they have gone to the academies and colleges, have never taken the courses too seriously, these facts are significant. They mean that education has too often been a thwarting of the spirit, an attempt to fit a square plug into a round hole, a pressure, a dead weight, rather than an unfolding. They mean, in short, that education has seldom, in practice at least, been reduced to a science.

We fail as Ptolemy failed, as Kepler failed, as the alchemists failed. We fail because we do not observe the true sequence of cause and effect in the life of the child. We shall succeed when we abandon our educational nostrums, our tonics, our pills, our philosopher's stones for turning ignorance into knowledge, our short-cut methods of salvation for making bad into good. We shall transform education into a science and educators into scientists when we give up these off-hand remedies, these false views of causal relationships, and come to recognize the simple fact that the child is an organism, and that the processes of growth and education must conform to the laws of organisms. We must part company with that fatal duality which separates body and spirit.

We must look upon the child as a unit. We must see in it an organism which includes both body and spirit, an integer. Then we shall substitute true causation for false causation. To do this, will be to follow in the footsteps of Newton, to write the Principia for education.

To make a good telescopic lens we must have glass of a certain quality, high refractive power, freedom from flaws, perfect transparency. Then we must carefully fashion it into a certain prescribed form. How utterly stupid it would be for us to spend all our time and energy upon one half of the problem—the fashioning of the lens—and neglect the quality of the material! We can imagine no one insane enough to do such a thing. Yet in education we are guilty of this very insanity. It is no wonder that the result so often fails to disclose heaven.

Another illustration. Carbonic-acid gas, ammonia, and water vapor constitute the chief food of plants. But you may surround a plant with just such an atmosphere, and yet get little growth if the soil be unsuitable, and the vivifying sunshine be not there to transmute this food into vegetable fiber. I often stand in our crowded schoolrooms with the feeling that we have provided an atmosphere rich in the materials of knowledge—possibly overrich—but that we have not seen to the root of the matter in trying to meliorate the life conditions of the child; and particularly that there is lacking the needed sunshine of a joyous, wholesome spirit to assimilate this food, and turn it into healthful human growth.

If a boy be up late at night; if he be routed out of bed early on the following morning, before the strong sleep of youth has spent itself; if he be flurried with little household cares, and the inconveniences of long transportation, is it a wonder that when at last he reaches the school, out of breath, and just in time to hear the morning lesson, we can do little with him? The marvel is that we should expect to. He had much better stay at home. Fond parents tell it of their children, and priggish children tell it of themselves, that they have not missed a single day at school in eight or nine or some other weary waste of years. There is no merit in this. The question is, What spirit did they take along, and what did the school profit them after they got there?

The life of an organism consists of nutrition, of growth, and of reproduction.

How often do we remember these cardinal facts in handling the human organism? The food of school children is of the most haphazard character; their growth, an accidental factor, and the holy mystery of fatherhood and motherhood too delicate a matter to mention to them. We err very grievously against the helplessness of childhood and youth in thus willfully neglecting the

known elements in their development, and turning so persistently to imaginary and fictitious causes. We are practically denying the principle of causation.

One may not be willing to say that the brain secretes thought as the liver secretes bile; but whatever theory of the origin and nature of the human spirit we may entertain, it must be admitted that the brain is its tool, and to have a wholesome manifestation requires a wholesome instrument. One need not be frightened—this is not materialism. I do not want the child to be merely a wholesome kitten—a beautiful, soulless Antinous. Let us think of him as a unit. When we say food, we have in mind ideas as well as oatmeal. When we say growth, we have in mind increasing perception as well as increasing stature. When we say reproduction, we have in mind the creative activities of the artist spirit, as well as the function of parenthood. But these things go together. It is neither an animal nor a spirit which presents itself at our door and submits to be educated. It is a monistic child.

We shall never have a scientific system of education so long as we persist in considering only a part of the child's day, and only the exterior aspect of his life. It is useless to argue that these matters belong to the province of parents, and not of teachers, for we all know that they are sadly neglected. The day school can not succeed without the co-operation of the home. It is rarely forthcoming. The average American parent will make heroic sacrifices to give his children what he is pleased to call an education. To him, this means sending them to school—five hours out of twenty-four, five days out of seven. In this he only illustrates his supreme faith in machinery. Under what influences do the children come? With what other children do they associate? What happens to them for the rest of the time?

Who asks these questions?

Nobody.

Who knows the answers?

Nobody.

We fail, then, so lamentably as teachers, not because we are altogether unwise, or because our methods are altogether bad, but very largely because we have deficient organisms to work upon. We are stupidly trying to make bricks without straw. We are trying to educate without employing the means by which alone education can be accomplished.

A curious case has recently come to my notice of a little English girl who suddenly developed a propensity for stealing. Her parents were naturally much mortified. The child herself was very unhappy, for she felt keenly the withdrawal of affection on all sides. In despair she was taken up to London, to a child specialist. He examined her carefully, inquired into her manner of

life, and finally pronounced the difficulty to be anæmia. He ordered her to be put to bed and given as many sweets as she would eat. In a short time the child regained her health, and with it her normal attitude toward life.

It is not probable that all moral disorders could be cured by so simple a prescription as sugar, but it is probable that the removal of organic disorders would remove many of their concomitants—moral disorders.

We close our eyes to this. The reflected image of our scientific *Zeitgeist* is faint compared to the deep-set images of a dead time-spirit. These images have their home in the traditions and superstitions of society. They are the reflection of ignorance, not of knowledge. They belong to a metaphysical rather than to an experimental age.

What are some of these images?

Baffling the clear recognition of cause and effect in the life of the child, there still lingers, and lingers persistently, that monstrous fiction of a diseased imagination which men call sin. It is the image reflected from a theological as opposed to a religious age. It is an obstacle in very truth, for it turns us away from causal terms to a false nomenclature and a false treatment. We say that a boy is bad when we ought to say that his life conditions are unfavorable; that his parents and teachers are unwise. It is difficult to search out the true cause of wrong action. It is easy to call it sin. This is a stubborn image. It persists, for it has back of it immense vested interests. We have in our midst a vast organization which rests its whole excuse for being upon the reality of sin. Its sole function is to circumvent this enemy, and conduct man to God and heaven. It would be disorganizing to admit that in all this it is fighting a poor human fetich, whose shadow obscures from humanity the gracious face of the Eternal. Yet to abandon this nightmare would simply be to return to the pure teaching of Socrates. The monstrous entity of sin had for him no real existence. He found in the world vast ignorance, and he fought it. Virtue he regarded as the fruit of knowledge, and he cultivated it.

Another hideous image comes to us from a vulgar and ascetic age. It regards the uncovered human body as an object of shame. With such immodest ideas of modesty we attempt the development of an organism which we keep studiously out of sight. Little Margaret is very picturesque in her quaint gown and big hat. They conceal the fact that her poor little body is stunted and undeveloped, and will but ill withstand the emotions and functions of womanhood. Brother Jack is also a lively figure in bright kilt skirt and velvet jacket. His neck is thin, but it is surrounded by a very broad linen collar. We look at that

and find him charming. His little legs are slender as broomsticks, but they are in thick black hose, and the red kilt attracts the eye. We look at that and are satisfied. He is active and noisy. We take it for granted that he is getting on finely. Were he in the bath-tub, we should think otherwise. Later, Jack goes to college. He breaks down. His mother says it is overwork. But this is not the truth. The truth is that he has not the brain power to cope with normal intellectual tasks. The fault is elsewhere than with the curriculum. In all this, the image cast by prudery makes us horribly unscientific. Worse still, it makes us hopelessly vulgar.

These are but two out of a large and bad company of images which to-day obscure the reflection of science in education. They make difficult the recognition of the simple fact that the child is an organic unity; and they make practically impossible the development of any system of education based upon this truth. So long as we allow this obscurity, and persist in this blindness, we shall have no science of education, however many schoolhouses we may build, for we shall be steadily doing violence to a principle which may not be violated—the sequence of cause and effect.

ECONOMIC USES OF NON-EDIBLE FISH.

By ROBERT F. WALSH.

FEW people are aware of the important uses to which non-edible fishes can be put, and fewer still have any idea of the thousands of millions of such fishes that are to be found along the coast of the United States. What some of these uses are will be learned from the following statement of Prof. G. Brown Goode, in his article on American Menhaden in Part V of the Report of the United States Commissioner of Fish and Fisheries for 1887. He says: "Millions of pounds of fish not fit for human food are allowed every year to escape from nets into the sea, which, if saved and rightly utilized, would be worth untold sums for fertilizers and feeding purposes. Of the fish saved and used for fertilizers, a large portion is ill prepared." And he continues, "A large part of that which is well made is exported to Europe, where its value is better understood and its use is more rational and profitable." Following these statements Prof. Goode says that "the total loss to our agriculture from all these sources is not capable of accurate computation, but certainly amounts to hundreds of thousands and doubtless to millions of dollars annually." But there are other uses to which these millions of fishes can be profitably applied; so that the value of our available

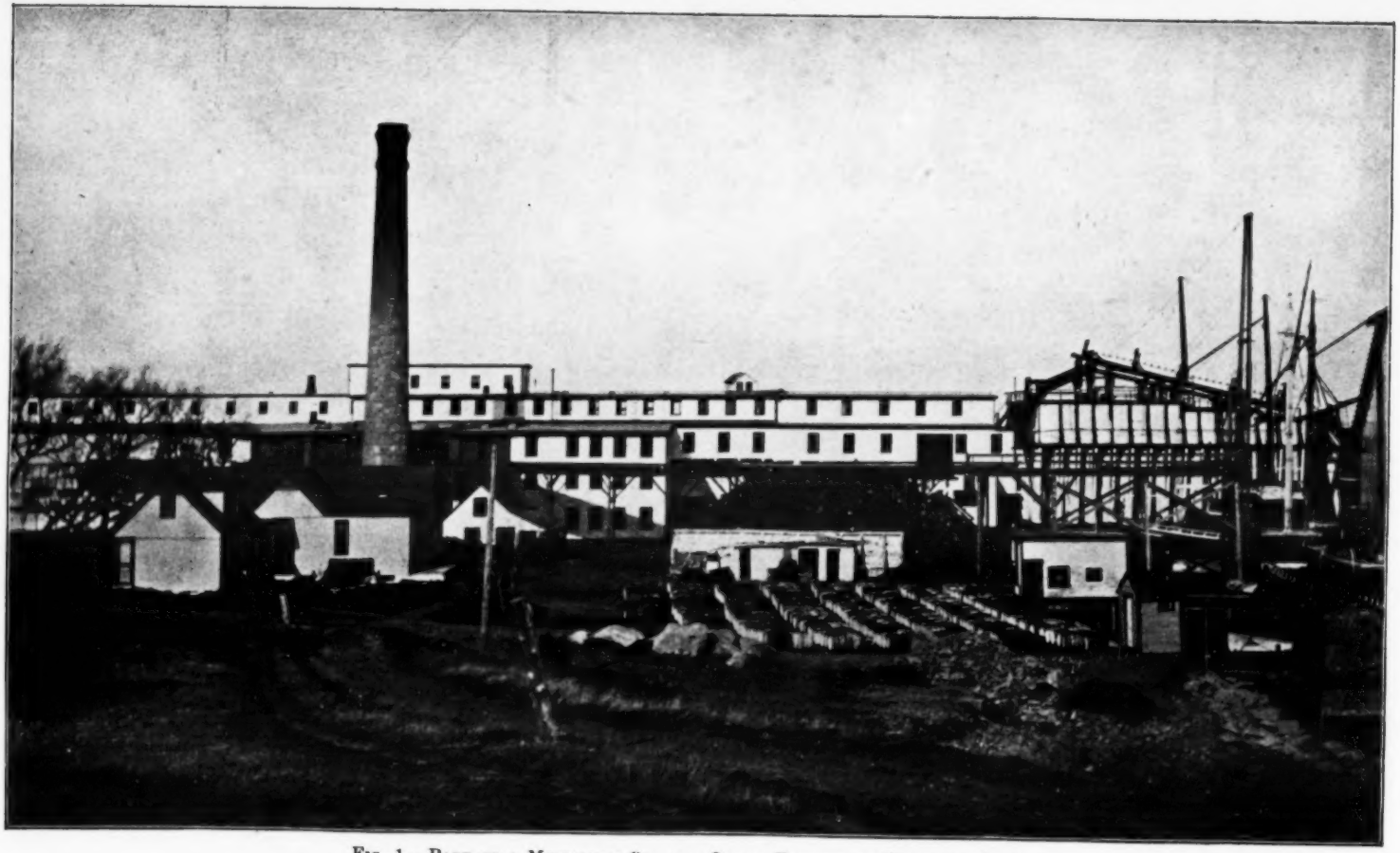


FIG. 1.—PART OF A MENHADEN OIL AND GUANO FACTORY AT TIVERTON, R. I.

non-edible fish supply probably exceeds that of those fishes which are used for food.

About twenty years ago a beginning was made in utilizing non-edible fish; but, from one cause or other—prohibitive State legislation, want of knowledge as to the best ways of obtaining fish products, and various other less important impediments—the industry is still far from that position of commercial and industrial importance to which it is justly entitled. But, notwithstanding the impediments to which I have referred, and although the operations of the factories engaged in the utilization of non-edible fishes are confined to the production of oil and guano from menhaden, in the year when Prof. Goode made the estimate above quoted over eight hundred thousand dollars' worth of crude and dried guano was produced, and 2,426,589 gallons of oil were obtained.

Bearing these figures in mind, and remembering that Prof. Baird estimated that "twelve hundred million millions" of menhaden are destroyed annually by bluefish—during four months in the summer and fall—and that this destruction is imperceptible in the myriads of these fishes which abound on the coast, it is apparent that, under favorable conditions, the value of menhaden to the commerce of the country could easily be developed to an extent that would at least equal the combined values of all our food fisheries.

It would be extremely difficult to fix the time when fish was first employed for fertilizing. We are assured, however, that long before the advent of Europeans on this continent, the Indians used menhaden for raising agricultural produce. The early colonists imitated the natives; and in 1632 Thomas Morton, of Virginia, wrote: "There is a fish (by some called shadds, by some allizes) that at the spring of the yeare pass up the river to spawn in the ponds, and are taken in such multitudes . . . that the inhabitants doung their ground with them." Eleven years previous to Morton's record Governor Bradford tells how "in April, 1621," the colonists began to sow corn, "in which service Squanto (an Indian) stood them in good stead, showing them both y^e^ manner how to set it and after how to dress & tend it. Also he tould them axcepte they got fish & set with it (in these old grounds) it would come to nothing; and he showed them y^t^ in y^e^ midle of Aprill they should have store enough come up y^e^ brooke by which they begane to build, and taught them how to take it."

Still later, and just one hundred years ago, in the Transactions of the Society for the Promotion of Agriculture, Arts, and Manufactures, instituted in the State of New York, Hon. Ezra L'Hommedieu says: "Experiments made by using the fish called menhaden, or mossbunkers, as a manure have succeeded beyond

expectation, and will likely become a source of wealth to farmers living on such parts of the seacoasts where they can be taken with ease and in great abundance. These fish abound with oil and blood more than any other kind of their size. They are not used for food, except by negroes in the West India Islands." This is absolute proof of the recognition of the value of men-

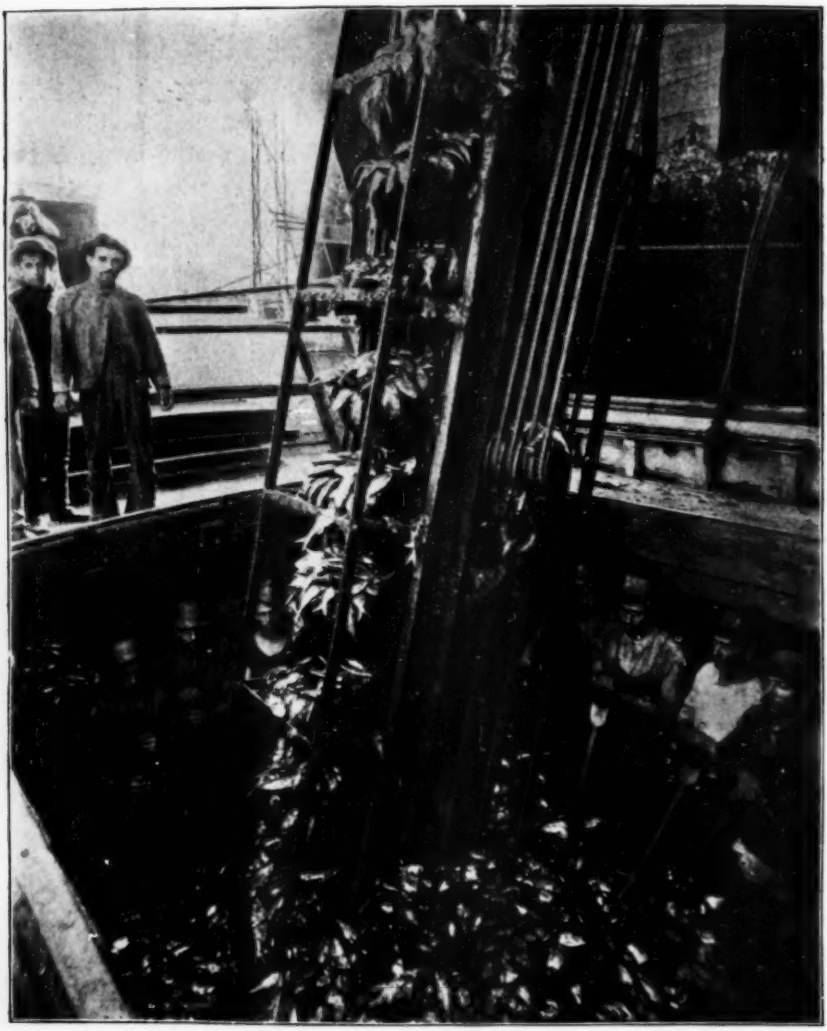


FIG. 2.—DISCHARGING A CARGO OF FISH BY TRAVELING BUCKETS.

haden for fertilizing purposes one, two, and nearly three centuries ago. But we have even stronger early testimony in the letter of President Dwight, of Yale College, who in 1804 writes: "No manure is so cheap as this, . . . none is so rich, and few so lasting. Its effects on vegetation are prodigious. Lands which

heretofore have scarcely yielded ten bushels of wheat by the acre, are said, when, dressed with whitefish (menhaden), to have yielded forty. . . . Such, upon the whole, have been their numbers, and such the ease with which they have been obtained, that lands in the neighborhood of productive fisheries are declared to have risen, within a few years, to three, four, and, in some cases, to six times their former value."

I shall give only one other authority for the use of fish and fish refuse as a fertilizer. In 1853 Mr. Ker B. Hamilton, Governor of Newfoundland, said: "In this island the manure universally applied to the soil is fish, consisting of the superabundant herrings and caplins in the process of decomposition, and generally without any earthy admixture; and the heads, bones, and entrails of codfish." From other sources we learn that in Norway, France, Japan, and in the British Islands, fish has been used, in its raw state, for fertilizing purposes, whenever it was found in great abundance.

Although we have evidence in the olden writings that the oil obtained from various fishes was used for lighting and other purposes, fish oil was practically unknown in commerce until about fifty years ago. Since then there have arisen hundreds of purposes to which it is daily applied.

The origin of the present menhaden industry was the discovery of an old lady, named Mrs. John Bartlett, of Blue Hill, Maine, who in 1850, when boiling some fish for her chickens, observed a thin scum of oil upon the surface of the water. "Some of this she bottled, and when on a visit to Boston soon after carried samples to Mr. E. B. Phillips, one of the leading oil merchants of that city, who encouraged her to bring more. The following year the Bartlett family industriously plied their gill nets and sent to market thirteen barrels of oil, for which they were paid at the rate of eleven dollars per barrel." In the following year this family made one hundred barrels. Then, the value of menhaden oil having become recognized, many oil presses—of a more or less imperfect construction—were established along the coast, and the industry developed so rapidly that within twenty years the yield of menhaden oil exceeded that of the whale (from the American fisheries). It now exceeds the aggregate of all the whale, seal, and cod oil made in the United States, and Prof. Brown Goode says, "As a source of oil, the menhaden is of more importance than any other marine animal."

The prime object of the first factories established for utilizing menhaden was the production of oil—the residuum, or "scrap," as the pressed fish is called, being looked upon as a secondary consideration. Nevertheless, this by-product was of equal worth, and in some years has exceeded in value the output of oil. This

"scrap" is a much better fertilizer than the whole fish; for the undesirable element—the oil, which "clogged the earth and made it unfit for tillage"—has been removed, and the "scrap" is left, containing plant food in proportions far exceeding those of any known natural fertilizer.

The process of extracting the oil from the menhaden is very simple. When the fish is delivered at the factory it is immediately placed in large iron tanks, containing about a foot deep of water. Heat is then applied until the mass begins to simmer, when the heat is turned off. In this way the fish is thoroughly steamed, and the oil cells are more or less separated from the flesh, so that the oil can be readily and thoroughly released in the presses. Often, when the fish is rich in oil, a considerable quantity exudes during the steaming process. This is drawn off from the top of the simmering mass and runs in troughs to the oil tank.

After the steaming, the fish is placed in "curbs" (circular vessels having perforated bottoms) and rolled to the oil presses. Here the oil is released by hydraulic pressure, and the remainder is simply the nitrogenous part of the fish, which is called "scrap."

FIG. 3.—STEAMING THE FISH.

In the factories of the United States Menhaden Oil and Guano Association the oil is not rectified; it is expressed in the simple manner that I have explained, and then shipped to the different oil merchants and refineries of the United States and Europe.

The preparation of the scrap, or fish guano, is also very simple. After the oil is released, the solid matter is taken to the drying boards—a large field covered with closely fitting grooved and tongued flooring—upon which it is spread to dry. At Tiverton

the drying field comprises nearly twenty acres. From first to last the greatest care is taken that no foreign substance shall become mixed with it. When it is sufficiently dry it is bagged for transportation, either to the manufacturer of artificial fertilizers or direct to the farmer. The total quantity of menhaden "scrap" manufactured during the nineteen years from 1874 to 1892 inclusive was 912,467 tons (dry and acid), and the amount made from other non-edible fishes and waste fish in the United States is esti-

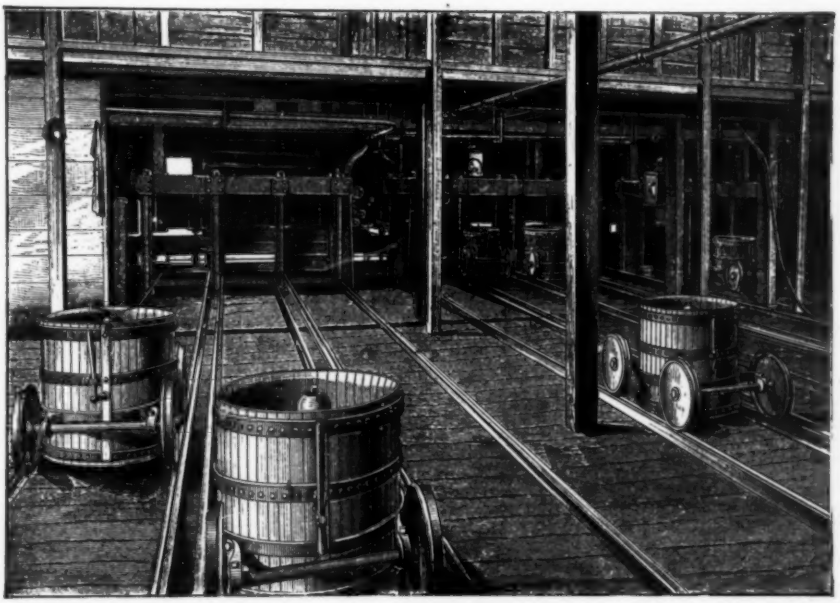


FIG. 4.—INTERIOR OF CURB ROOM IN FACTORY, SHOWING THE IRON CYLINDERS IN WHICH THE SCRAP IS PRESSED.

mated at 150,000 tons. By analysis, the average percentage of nitrogen was found to be eight per cent in the dry scrap and six per cent in the acid, while the acid guano contained four per cent of phosphoric acid, and the dry seven per cent. This gives us a total plant food (nitrogen and phosphoric acid) of 135,000 tons, or about $31,000,000 worth at the present rate fixed by the New England experiment stations.

The average price at which this fish guano was sold was fifteen dollars per ton for the acid scrap and twenty-five dollars for the dry. The guano from the Peruvian deposits which has been imported into this country during the past thirty years contained from four to eight per cent of nitrogen, with about an equal percentage of phosphoric acid, and millions of dollars have been paid for it at the rate of from forty-five dollars to eighty dollars per ton. Why such a great disproportion exists in the prices seems

to be unanswerable, and it will seem still stranger in view of the fact that the fishermen of Lofoden, one of the Norwegian Islands, should readily get forty-five dollars per ton for dry scrap made by them from cod refuse. These apparently anomalous conditions can, however, be partially accounted for from the facts that the Peruvian guano is sold in a finely powdered state, and perfectly dry, and the Lofoden islanders grind their scrap after drying it upon the rocks by the sun's heat. In this condition the nitrogen is more quickly assimilated, and the effects more speedily appreciated by the growing crops. But this process could easily be applied to the American product, and I have no doubt but that ground or machine desiccated fish guano will form one of the chief features of our manufacturers as soon as favorable or rather just legislation will enable the manufacturers to calculate upon more certain supplies.

Mr. William Bowker, of the Massachusetts Board of Agriculture, estimates that the 135,000 tons of plant food, referred to earlier, contained more than sufficient phosphoric acid and enough nitrogen for "3,200,000 acres of corn, of fifty bushels each, or 7,000,000 acres of potatoes of one hundred bushels each."

Let us now glance at the figures of the menhaden oil production. From 1874 to 1892, inclusive, the quantity of oil expressed from menhaden amounted to over 46,000,000 gallons—about 165,000 tons. This was sold for prices varying according to the abundance of the fish, from fifteen to twenty-one cents per gallon in the seasons of 1885, 1886, and 1887, to thirty-five cents in 1879, and forty in 1881; the price being thirty-two to thirty-three cents during the past year (1893); so that the average price was about thirty cents for these 46,000,000 gallons, or $13,800,000 for the oil product of the menhaden fisheries for nineteen years—equivalent to $725,000 per annum. Add to this the average yearly value of the acid and dry guano, as computed by Mr. Bowker, and we find that the menhaden industry has enriched the country by $2,360,000 annually since 1873.

The oil has been used largely in tanning leather, and as the basis for many oil paints and varnishes, while a great deal of it is consumed for lighting purposes in our mines and elsewhere. The quantity of oil annually exported is also very large, and the demand for it is so great that markets could readily be obtained for ten times the quantity. These are startling facts, and facts that deserve most studious consideration. We have been reaping over two million dollars' worth of products from menhaden and other non-edible fish annually, despite repressive legislation in three of the States in whose waters those fishes abound most plentifully; we pay millions of dollars annually for imported fertilizers; we have agricultural and industrial demands for ten times the

FIG. 5.—PART OF A DRYING FLOOR.

amount we have been producing; and we are assured beyond question that an abundance of fish, quite equal to these demands, swim along our shores, and that the capture of a sufficient number of them would not appreciably affect their plentifulness. Surely the legislation that prevents the development of this source of wealth must be at fault somewhere.

Such legislation exists in Maine, Massachusetts, New York, and Virginia; and the conditions under which these laws were passed deserve to be cited here. In considering these repressive enactments it will be apropos first to examine the arguments urged in favor of them. Three principal objections to the menhaden fisheries are made: First, that fishing for menhaden, mackerel, or any other fish with a purse seine (the appliance now used) depletes the supply of these fishes; second, that menhaden is the food of many of the food fishes, and the depletion or "driving away of the shoals" of this species by seining, forces the food fishes—mackerel, striped bass, bluefish, etc.—to seek other waters; and, third, that the enormous captures of menhaden for the purposes of making oil and guano prevent the procuring of bait for our cod and other fisheries; it being included in the third objection that inasmuch as cod, mackerel, bluefish, and other species are captured with menhaden bait, this latter fish is a natural food of the food fishes. It is also claimed that the shoals of fish are frightened by the purse seines, so much so that they cease to frequent the shores in the same abundance. These constitute in brief the objections to the capture of menhaden for oil and guano, and form the basis of the reasons why the States of Maine, Massachusetts, New York, and Virginia passed prohibitory laws.

Let us now examine the other side of the question. Before the Committee on Merchant Marine and Fisheries of the United States Senate, February 17, 1892, Mr. William F. Brown, of Philadelphia, said: "The annual value of our" (the Menhaden Association) "product for the last twenty years has averaged $1,500,000, more than two thirds of which is paid to the two thousand men employed. And when you consider that every dollar of this—more than $25,000,000—is a permanent clear addition to the wealth of the nation, because the crude material is taken from the sea; and when you have seen how generally the whole people are interested, directly and indirectly, in our success or failure, you will stand amazed at the recital of the persecutions and legislative wrongs to which we have been subjected." Further on Mr. Brown made a general denial of all the objections claimed by the opponents of the menhaden industry. This statement is backed up by the evidence of Mr. Eugene Blackford, of New York; of Captain Nathaniel Church and his brother Daniel T.

FIG. 6.—SHOOTING A PURSE SEINE.

Church, of Tiverton, R. I.; and by the opinions of Captain J. W. Collins, of the United States Fish Commission, Prof. G. Brown Goode, and many others scientifically and *practically* engaged in deep-sea and coast fisheries. For instance Captain Collins says:

"The researches and inquiries made by the Fish Commission, I think, show conclusively that certain species of migratory fishes, like, for instance, the mackerel and menhaden, are subject to influences which determine their abundance outside of anything that can be done by man—influences that are much more potent than man's are." In proof of this statement both Captain Church and Mr. Collins have drawn attention to the facts that, in the case of mackerel—and menhaden are, like mackerel, migratory and similarly influenced—seasons of scarcity may be and are followed by years of comparative plenty; and a series of seasons of scarcity may be followed by a gradual increase until an abundance is reached that is very surprising.

This disposes of the claim that purse-seine fishing affects the natural scarcity or abundance of fish on the coast. Mr. Church and Mr. R. E. Earle authoritatively deny the statements that food fishes are taken in the nets of the menhaden steamers. And Mr. Earle says that, when engaged, as an expert of the United States Fish Commission, to inquire into the menhaden fisheries, he did not see enough food fish taken for the table of the steamer as the result of several hauls of menhaden.

Right here it will be interesting to describe the method of seining menhaden, showing how it is almost impossible to capture food fishes other than migratory fishes in the purse seines. The steamers used in the menhaden fishery average about seventy-five tons register and have a carrying capacity of nearly one hundred and fifty tons. Each steamer is manned by twenty to twenty-five men, of whom sixteen are fishermen. When a school of fish is sighted, two boats put out from the steamer, each boat containing eight men. From one of these boats the net is "shot"—the other holding the top and foot lines of one end. The usual length of a purse net or seine is about eighteen hundred feet and the depth sixty to one hundred and twenty feet. As one of the boats rows around the school of fish, the net is thrown out from the other, and when the circle is made, both ends of the "bottom line" are drawn. This makes the "*purse*"; but it also allows the "bottom fish," which are practically all food fishes, time to escape; so that as a rule no fishes except the menhaden, or whatever kind of fishes are inclosed on the surface, are captured by the purse seines. The top lines are then drawn, and the bag or purse completed. The contents are then towed along to the steamer, where they are hoisted by steam, and the seine emptied into the "hold."

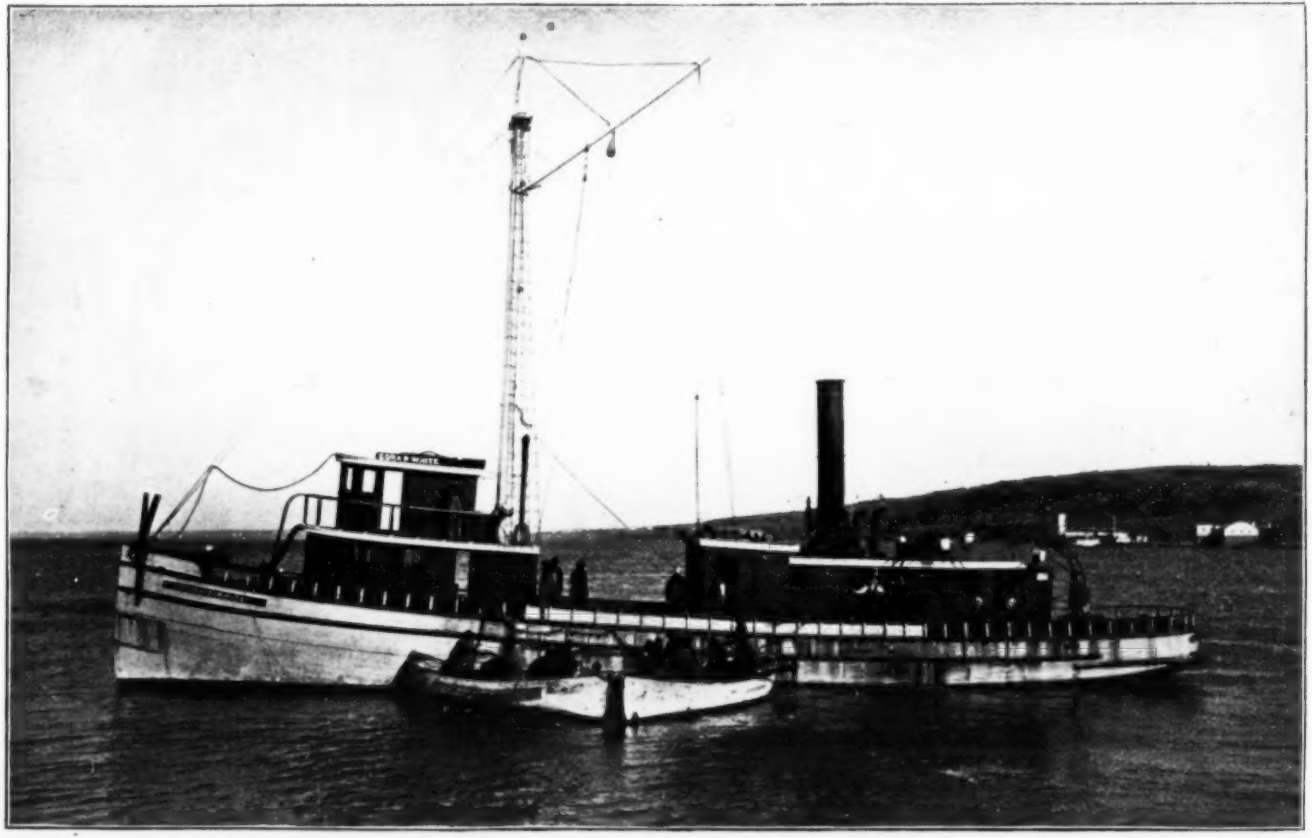


FIG. 7.—A MENHADEN STEAMER, SHOWING PURSE SEINE ABOUT TO BE EMPTIED AFTER A HAUL.

It should be stated here that the meshes of every purse seine employed in the menhaden industry are two and seven eighths inches square, so that it is practically impossible to capture any immature fishes in these nets.

Aside from the operations of the factories, menhaden are used as bait for food fishes; a small quantity is salted and exported to the West Indies, where it is eaten by the negroes; and many more are plowed into the soil by farmers along the Atlantic coast, as has been the custom for centuries.

The question of the menhaden being used as food by the food fishes is practically disposed of by Dr. Bean, the ichthyologist of the United States Fish Commission, who testified that, having examined the stomachs of numbers of bluefish and other food fishes, he failed to find any evidence of the menhaden except in the form in which it is used as a bait for "chumming," and only in a very few cases was it present at all. Mr. Atwood, of Bristol County, Massachusetts, whose experience as a practical fisherman extends back to 1816, makes the following interesting statement:

"The great changes in our fisheries have been caused by the bluefish. . . . When they first appeared in our bay I was living at Long Point (Provincetown), in a little village containing some two hundred and seventy population, engaged in the net fishery. The bluefish affected our fishing (mackerel, menhaden, etc.) so much that the people were obliged to leave the place. Family after family moved away, leaving that locality, which is now a desolate, barren, and sandy waste." Passing over the depredations of the bluefish, Mr. Atwood says, "I firmly believe there is no necessity for the passage of any general legislative act for the protection or regulation of our sea fish and fisheries."

J. M. Rimbaud, a famous French ichthyologist and practical fisherman, says that the *migratory* fishes can not be diminished by overfishing; but that local fishes might be exterminated by constantly fishing for them. The Royal Commission appointed by Her Britannic Majesty's Government to inquire into the condition of the fisheries of Great Britain and Ireland, which consisted of Prof. Thomas Henry Huxley, Right Hon. James Caird, and the Right Hon. George Shaw Lefevre, after three years of exhaustive inquiry reported: "We advise that all acts of Parliament which profess to regulate or restrict the modes of fishing pursued in the open sea be repealed, and that unrestricted freedom of fishing be pursued hereafter." I heard Prof. Huxley state positively, in 1883, that after many years of study of the question he had come to the conclusion that the supply of migratory fishes, especially the herring, was inexhaustible.

I think I have now told enough about the non-edible fish in-

dustry of the Atlantic coast to show that it is an important source of national wealth, and I believe it will reasonably be deduced, from what I have written, that nothing but restrictive laws in several States prevents it from becoming of vastly greater importance.

PECULIAR SOUND EFFECTS.

By A. A. KNUDSON.

IN this article we propose to consider some of the peculiar features and effects of sound as we meet them in our everyday life, giving special reference to that very oft perplexing phenomenon the *location* of various sounds. In order that these remarks shall not extend beyond reasonable limits in our treatment of this broad subject, we shall confine them to sound effects as they originate *indoors*, and not so much to the origin and transmission of sounds in the atmosphere. The inability to determine at once whence a sound comes, or, as is often the case, locating it in the wrong place, occasions frequent trouble and annoyance, as we shall show by incidents in our own experience, extending over a number of years.

In order that those not familiar with the subject may obtain a fair idea of the peculiar effects of sound, as we shall herein illustrate, let us look briefly at some of its principles. In the science of acoustics, *sound* is simply vibrations or pulsations originating from an unlimited variety of causes, varying in amplitude, pitch, etc., passing through the intervening air, and acting upon the organs of the ear. The phonograph gives us an excellent illustration of the composition of these vibrations, for by examining with a magnifying glass the cylinder upon which the human voice has been placed either in spoken words or vocal music, we find all the vibrations which go to make up the different characteristics of sound faithfully recorded in the indentations upon the cylinder. I say *faithfully* recorded, because their correct reproduction is a proof of this—the result being the same also if other than vocal sounds are recorded upon the cylinder, such as music from instruments either single or combined.

If we follow the lines made by the vibrations closely, we shall see in the indentations deep and coarse punctures which represent the loud base notes of the male singer or speaker, while the fine, light, and more frequent indent represent the high notes of either a male or a female voice, and the same effect is produced by the vibrations of sounds made by musical instruments. The phonograph, therefore, enables us to capture, as it were, all manner of sounds, and to give them optical expression, while

their reproduction is the wonderful feature of the whole performance.

I was once present by invitation of Mr. Edison to witness a phonograph test in his laboratory at Orange, N. J., and by way of illustrating the power of reproduction of that instrument will state the result as witnessed by me. Some fifteen or twenty phonographs were placed in a semicircle in the room, all their cylinders running, and a band of music, including a piano, stationed near the center. After the band had played a selection from some popular opera, we examined their power of reproduction by putting on the ear tubes, and, beginning at one end of the row in company with Mr. Edison, tried each phonograph.

It was found that while some reproduced the music not as loud or as clearly as desired, owing probably to imperfect adjustment, the most of them were remarkable for their loudness of sound, and so clear and perfect that the sound of each instrument such as the piano, cornet, etc., could be distinguished *separately*. These cylinders were taken off and, after being labeled, filed away for future use. In the phonograph Mr. Edison has given the world a most useful and valuable invention; for, beyond the fact of its commercial value, it is a most important educator in the science of acoustics, as we have attempted to point out.

Many illustrations may be found in *electrical inventions* where the vibrating construction of sound is taken advantage of—for instance, the musical telephones of Prof. Gray and Edison, and such ingenious inventions as the harmonic telegraph of Gray, and the railway induction telegraph of Phelps and Edison. All these and many others employ the vibrating effect of sound to accomplish the desired results.

If we look for more common illustrations we may easily find them about us, such as the circuit breaker in the medical battery. By manipulating the adjusting screw, changing the number of vibrations per second, a variety of notes can be produced, from a a low rattle to a high, fine tone. The ordinary "buzzer" now common in business houses, which is largely taking the place of the electric bell, gives forth a note more or less musical according to the number of vibrations per second to which it is adjusted. The wings of the humming bird as well as those of insects furnish further examples of musical notes (not always welcome) by the rapid action of their wings against the air.

It will be observed, as this question is studied, that sound vibrations to be musical must be *regular*, otherwise they become simply noise. Prof. Tyndall, in his admirable work on sound, referring to this part of the subject, says that "a musical sound flows smoothly and without irregularity, and this is secured by rendering the impulses received by the tympanic membrane per-

fectly periodic; a periodic motion being one that repeats itself." And, again, quoting from Tyndall: "To produce a musical tone we must have a body which vibrates with the unerring regularity of a pendulum, but which can impart much sharper and quicker shocks to the air. The pulses, on the contrary, which produce *noise* are of irregular strength and recurrence." These illustrations will no doubt afford a fairly clear understanding of the creation and composition of sound, and we will now consider some of its effects.

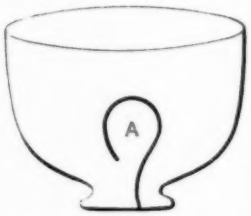
One peculiar phase in sound effects is the sympathetic response of objects in the vicinity of a sound or note, such as the responding vibrations of a violin string when a note on the piano is struck with which it is in harmony.

This peculiar effect, however, is by no means confined to musical instruments, for should there be any object in a room which by accident happens to be so placed as to be in unison or tune with some note of a piano, that object will respond by taking up the vibrations of the note sounded. This responding note being often accompanied by a disagreeable jarring sound (due to the article touching some object while vibrating), interferes with the harmony and is often the cause of much annoyance to ladies and others who may be playing the piano; besides, these foreign sounds are so deceitful as to their location that usually they seem to come from the piano itself, and it is generally very difficult to convince a lady that they are anywhere else, and in the ladies' opinion a piano tuner must be sent for as soon as possible. An instance or two which happened in my experience will illustrate this.

The first case happened in my own home a few years ago. My wife and myself were in the parlor, she playing the piano. Presently she stopped and impatiently said, "There, this piano is not right yet, and that tuner has been here three times, and this is the note he fussed over so long" (pounding on the same), "and it's just as bad as ever." The fact was, the last time the tuner called he went away very mad, stating that he never had had such a case in all his experience. Knowing all this, the remark of my wife set me to thinking, and I asked her to pound awhile on that bad key. Upon listening carefully about the piano the jangling noise did really seem to come directly from it; but determined not to be deceived, I started on a tour of investigation, first satisfying myself that there were no loose objects upon the piano itself. I began to look about the room among *bric-à-brac*, mantelpiece ornaments, etc., now and then receiving such encouraging remarks from the performer as "There is no use looking away over there for that noise, it's right here in the piano; don't you hear it?" But I said, "Never mind, keep on pounding."

With the sense of hearing exercised at its best, I continued the search, but had almost given it up when, upon crossing the room and passing under the chandelier, I thought I heard the jangle above my head. Getting upon a chair, I listened carefully at each one of the glass globes, and finally came to one where I could hear the jangle quite distinctly. Upon looking at this globe carefully I discovered a very peculiar crack in it. This crack in shape was almost a complete circle, but a small stem or portion of glass at its lower edge held the piece in place, so that it was in condition to respond to the vibrations of that note of the piano with which it was in tune, and in this case it was *the one* that was being sounded.

The accompanying sketch will give a very fair idea of the position and shape of this piece of glass at (A). Pressing a finger against it in order to stop its vibrating, and to be quite sure that I had found the trouble, I asked the player if she heard the sound then. After several vigorous thumps she was obliged to confess that she did not. Taking away my finger and allowing it to vibrate as before, I asked again, "Do you hear it now?" The answer this time was, "Yes, it is there yet." Removing the globe, I announced the fact that the piano *was fixed*, much to the astonishment of the player, who found the statement correct. This incident illustrates how even the practiced ear of a musician can sometimes be deceived as to the location of sounds in music—to say nothing of the ladies, who would be excusable under such circumstances, as their sense of hearing is not expected to be so perfect as to detect such peculiar phases of sound.



Another interesting feature of peculiar sound effects is illustrated by this incident. While this loose piece of glass would respond and vibrate to *one* note of the piano, no other note would affect it, not even the sharp or flat of the one that caused it to respond.

If these responding objects, however, were free to vibrate without touching anything, such as a violin string, there would be no jangle, for as in the above case the edges of the broken piece of glass touched that of the globe, which caused the discordant sound, which I have termed for want of a better name the *responsive jangle.*

Another case similar to the above occurred in a house where I was once stopping in Nova Scotia. A piano with a bad note was fixed by simply opening an inside shutter of a bay window at the opposite side of a parlor from the piano. The latch of one shutter was lightly resting against the edge of another and

caused the jangle when one particular note was struck. The lady player had previously declared that she would send for a tuner the next day, and laughed at my attempt to fix it by hunting about the room while she pounded. However, she did not conceal her surprise when the trouble was removed, and admitted that there was something about this sound business that she did not quite understand.

In regard to locating these jangles, however, I will say that it is not always so easy. It requires some practice before the ear becomes capable of locating with any degree of success the direction of sounds of this kind. This was my experience with the first piano jangle, that of the cracked globe, which was quite difficult; that of the window shutter was easier, as well as many others which I have located since. A correct musical ear is also an important adjunct in the case. I have often observed the responsive jangle in concert halls, churches, etc. One church in particular in Brooklyn that I often attended had a responsive note high up in one of the windows which I was able to locate from the pew where I sat. I formed a sort of secret attachment for this jingling note, and I looked as much for it to respond every Sunday when the organist touched the proper key as for the audience to respond to the readings of the service.

Business called me away from home and church, and after a lapse of four or five years after returning home one of the first things I looked for on again attending church was my jangle. But alas! it was gone. During my absence inside windows had been placed over all the windows in the church, and my jangling friend was silenced. No doubt the cause of this jangle was some detached piece of glass from a cracked window pane, but it was too high up to be seen.

This locating of jangles originating from musical notes having become somewhat of a hobby with me, being almost always on the lookout for them, many curious instances similar to those I have mentioned could be related, but I will give only one other, which was the first that ever came under my notice, and which took place several years ago.

This most peculiar case happened in a church on an Easter Sunday. During the singing of a hymn I at once became conscious of an occasional discordant sound quite near where I stood (the congregation were standing), and this jangle was so marked that the music for me at least had no further charms. After listening in various directions I finally located it as coming from the mouth of an elderly lady who was singing with a good deal of vim in the seat in front of me. The fact was, her false teeth were loose, some of them at least, and the effect, notwithstanding the surroundings was to me more ludicrous than inspiring. In

this case it will be observed that the original sound and the jangle both came from the same place, so that it was not so difficult to locate.

There was no mistake about it, as the old lady sang through each verse, and at every verse the jangle appeared. She, however, seemed totally unconscious of any discordant effect in her vocal effort, and I have no doubt did not notice it at all.

The difficulty of locating sounds correctly may be illustrated in one way by the advantage the ventriloquist takes of this peculiarity, for in the exercise of his art he can speak in such manner that his voice appears to come from an image beside him, or from some distant place. Analogous to optical delusion, the ventriloquist might be well termed an exponent of sound delusion; and, again, the attempt to deceive an audience as to the source of sound by a supposed performer on the stage going through the motions of playing upon a cornet or other musical instrument while the real performer is behind the scenes is often successfully practiced. I was once present at a practical test made before an audience which will further illustrate how difficult it is to determine whence a sound comes. A gentleman took his seat in a chair upon the platform and was blindfolded. Another party held a snapper sounder in one hand and would produce the snap now directly over his head, now to one side, behind his back, etc. At each sound of the snapper the blindfolded party was requested to point in the direction from which he thought the sound proceeded. In almost every attempt he pointed in the wrong direction.

As a result of observations which I have made among animals, there is a wide difference between them as to the ability of distinguishing and correctly locating sound; for instance, men and women have not such an acute sense of quickly locating a sound as some of the four-footed animals, such as the rabbit, mule, the cat, and some species of dogs. It is quite probable that the ability these animals have to move their ears about, and long ears at that, accounts for the quickness they have for determining the direction of a sound. I have often tried the experiment of testing this sense of correctly locating sound with a cat by imitating the squeak of a mouse by whistling through the teeth. The first squeak or two would result in the cat springing up and, with ears erect and moving about, listen for the next sound; at the second attempt the cat would as a rule look directly into my face, as much as to say, "You can't fool me that way," would settle down again to its nap, and no further imitation squeaks would start it up again.

The not infrequent result of any unusual sound behind a mule illustrates how well his sense of hearing serves him in this re-

spect. It is pretty well known that the mule does not wait to turn his head to see if he has correctly located the sound, but will let his heels fly first and look around afterward. The *rabbit*, by reason of his long ears in proportion to his size, has probably the most correct sense of locating sound of all animals.

We mortals, however, not having long ears or the ability to move those that we have, often make sad mistakes in our attempts to correctly determine the source of various sounds. In other words, the hearing facilities coupled with instinct in animals are far superior to the hearing facilities coupled even with reason in human beings.

Among human beings, however, the Indian is probably the most correct in his interpretation and location of sound, whether in ascertaining the presence of a foe or in search of game his sense of hearing in this respect through long practice attains a much higher state of perfection than that of people in various commercial or professional occupations. From my observations I should say that such animals as I have mentioned would come first on the list as the most correct locators of sound, men next, and women last. I have already shown to some extent the difficulty ladies have in this respect, and by way of illustrating further will relate an incident which occurred in Brooklyn some years ago, which will show how easily they can be mistaken should they depend upon their first impressions. Soon after the introduction of that very useful invention the pneumatic door check, designed to prevent doors from slamming, one was fixed on the entrance door of the general post office on the inside near the top. When the door closes, as every one knows, the check emits a slight hissing sound, due to the air in the cylinder escaping through a small hole. (Some later designs are without this feature.) This hiss, which is very similar to the sound often made by boys and men through their teeth in attracting attention, but considered rather insulting if applied to ladies, was the cause of a good deal of trouble one day.

A lady called at the office, and no sooner had the door closed behind her, when *citt*. Immediately fastening her flashing eyes upon a clerk at the stamp window, she exclaimed: "So, you are the one; I have found you at last!" and then bolted into the presence of the postmaster, where she lodged a serious complaint, viz., that she had been insulted by the aforesaid young man, and this was not his first offense, for every time she had come into the office lately "that man would go *citt* with his teeth." The astonished postmaster immediately sent for the accused, who heard the charge against him, but of course indignantly denied having made any such sound through his teeth, never saw the lady before, etc., etc. Finally, after the rumpus had quieted somewhat,

an idea occurred to the postmaster, who was of a practical turn of mind, and he asked the lady to step out to the door a moment. Opening the door at which she entered, he let it close again, when *citt*, that insulting sound again. The lady was asked if that was the noise she heard, and she said, "Why, yes, that's it." Then the obliging postmaster explained to her the new door check, pointing up at the top of the door, how it worked, etc., much to the surprise and mortification of the lady, who apologized and soon left, muttering about the "new-fangled things men are always getting up."

The point I wish to make in this illustration is that the lady was completely deceived as to the location or source of this sound, and unfortunately put it in the wrong place, viz., in an innocent man's mouth several feet in front of her, when as a matter of fact it came from directly over her head. Many familiar instances of the inability of locating the source of vocal or other sounds occur every day, but I think sufficient has been said to at least put those on their guard who may read this article, should they meet with any such experiences.

In conclusion, I would suggest that the first impression of the origin or source of a sound should not be taken as absolutely correct if it is a case of importance, such as a responsive jangle produced by a musical note or accusing wrongly some innocent person, as in the case of the lady and the whistling door check. Should your piano be afflicted on one of its notes by an apparent bad sound or jangle, before sending for a tuner investigate a little on your own account while some one sounds the key.

If the trouble is due to a jangle in some part of the room, a tuner, if sent for, no doubt would "fix it," but he would in all probability tune the supposed bad string a little high or a little low, and for the time avoid the jangle in that way, collect his fee and depart, when the trouble would afterward reappear again as bad as ever. I would say further that I am not aware of any existing rules that will direct one in the correct location of sound. We can only use our ears and common sense as occasion requires, and if sometime errors are made they should not be wondered at, when the deceptive nature of the phenomena of sound is considered.

THE behavior of the luminiferous ether near matter has been investigated by Prof. Oliver Lodge. The question bears upon that of whether the earth in its motion carries the ether of space with it. Prof. Lodge moved a lump of matter and ascertained whether the velocity of light in the space near it is affected by the movement. He found no such effect, and concluded that the ether slips through a solid like wind through a grove of trees; and that the connection between ether and matter is not mechanical.

RELIGIOUS BELIEF AS A BASIS OF MORAL OBLIGATION.

By Prof. E. P. EVANS.

FOLLOWING the primitive period of tribal ethics* comes a second stage of social and moral development, which Mr. Maine calls the supersession of the bond of blood by the bond of belief. Ethnocentric attraction gives way to what might be called theocentric attraction, and a broader and more spiritual sort of association is formed, having for its basis, not consanguinity, but conformity in religious conceptions. The god takes the place of the human progenitor of the tribe, or rather grows out of his deification in the evolution of ancestor worship, which is probably the oldest of cults.

Nevertheless, in this case, the fundamental principle of primitive society, which makes friendship coextensive with kinship, is not abrogated, but only enlarged in its application, causing those who worship the same deities or propitiate the same demons to enter into fraternal relations and call themselves brethren.

The canonical prohibition of marriage between persons connected merely by the artificial ties of a religious rite, such as sponsors and baptized infants, godfathers, godmothers, and godchildren, proves how intimately the idea of ritual relationship was associated with that of real relationship in the minds of those who established and perpetuated this institution. This fiction of sacramental kinship was at one time carried so far in the papal Church as to forbid the sponsor to be joined in wedlock even to the parent of a godclild. Cohabitation between a *patrinus* and a *matrina* was regarded as incest until the Council of Trent removed the ecclesiastical bar to such unions. The fact that they had assumed the position of spiritual parents to one infant prevented them from becoming the real and lawful parents of another infant. The importance attached to the name-day, which in most Catholic countries quite supplants the birthday as an anniversary, is also additional evidence of the vigor and vitality of primitive conceptions as embodied in ecclesiastical institutions.

Religion is, in fact, as Schelling observes, the strongest cement of primitive society, and the influence which contributes more than any other to the evolution and organization of the nation and state out of the tribe. Plutarch says: "Methinks a man should sooner find a city built in the air, without any ground to rest upon, than that any commonwealth altogether void of re-

* See Popular Science Monthly, January, 1894.

ligion should be either first established or afterward preserved and maintained in that estate. For it is this that contains and holds together all human society and is its main prop and stay." Hegel expressed the same idea when he asserted that "the idea of God forms the general foundation of a people." Herbart calls attention to the pedagogical and disciplinary value of religion in the early stages of man's development, since it teaches him to subordinate present desires to future welfare, to look to the remote results of his conduct, and to sacrifice momentary pleasures here to permanent advantages hereafter.

But the ordinary experiences of life, especially in a cold climate, are quite as effective in inculcating thrift and enforcing the first elementary principle of domestic and political economy—that a man can not eat his pudding and keep it too. Stress of hunger emphasizes the necessity of laying up stores of provisions against time of need, and teaches foresight and forehand more directly and more forcibly than any hypothetical relation of man to the gods could do.

Originally the tie of religion must have been identical with the tie of relationship, and the brotherhood of belief coextensive with the brotherhood of blood, since all members of the same family or tribe would naturally adore the same domestic or tribal deities. Without this acceptance of the tribal theology and traditions by every individual of the tribe, the public peace would be constantly disturbed and the very existence of primitive society imperiled.

With the lapse of time and the increase of intelligence, however, vague wonder and ignorant worship would give place in more thoughtful minds to obstinate questionings, blank misgivings, and stubborn skepticisms, leading logically and inevitably to open schisms, and resulting in the formation of new communities of faith, crystallizing around the nucleus of a vital religious conviction. It was then proved, what all later history confirms, that spiritual affinities have a stronger cohesive attraction than natural affinities, and that, in every case of tension, the latter are sure to yield and be rent asunder.

Even the founder of Christianity, who professed to proclaim a gospel of peace on earth and good will to man, foresaw and did not hesitate to declare that this sundering of the closest consanguineous connections and division of families into hostile factions would be the necessary consequence of his teachings. He spoke of his doctrines as a sword destined to sever the nearest ties of natural affection and affinity, setting the son at variance against the father, and the daughter against the mother, and converting the members of a man's household into his bitterest foes.

The center of cohesive attraction, which binds the new com-

munity so firmly together and so relentlessly ruptures all older associations, is the creed, or what is known in Christian theology as the symbol, the same term that, as we have already seen, was used by the Greeks to denote the token or pledge of hereditary hospitality and friendship between families, which furnished a basis for the formation of treaties of amity and commerce between tribes.

Strictly tribal religions never proselytize. Instead of seeking to share with alien tribes the favor and protection of their gods, they wish to monopolize whatever power and patronage may be derived from this source as a means of rendering themselves superior to their enemies. This was the case with the ancient Hebrews, who never thought of sending missionaries into other lands to make converts to Jehovah, but would have condemned such a procedure as treasonable. It is true that Jesus, in his denunciation of the Pharisees, declared that they "compass sea and land to make one proselyte"; but this reproof referred to their zeal as a political party in winning adherents among their own countrymen, in order to supplant the more liberal-minded and less rigidly ritualistic Sadducees in the Sanhedrin.

Jesus himself evidently never intended to break away from Judaism and to become the founder of a new religion. According to his own statement, he was "not sent but unto the lost sheep of the house of Israel." His mission was not to destroy, but to fulfill; not to abrogate, but to accomplish the law. He sought to give a spiritual interpretation to ancient precepts and injunctions; to revivify and rehabilitate the moral sentiment, hitherto dwarfed and deformed under the heavy burden of a perfunctory ceremonialism; and to enforce the commandments of God free from all incrustations of the traditions of men.

Curiously, and yet naturally enough, it was out of the very strictest sect of the Pharisees, so severely rebuked on account of their proselytic spirit, that the great proselyte Paul came—the man whose breadth of view and energy of purpose changed a local reformatory movement, which seemed to have been practically suppressed by the crucifixion, into a world-wide religion, by emancipating it from the fetters of Mosaic formalism, taking it out of the narrow *ghetto* of tribalism, and imparting to it a universal character. In this bold effort to turn apparent disaster into permanent victory, by breaking through the barriers of Judaism and preaching the gospel to the Gentiles, he met with the most determined opposition from the near kin and personal friends of Jesus, as well as from the principal disciples in Jerusalem.

To this process of development—by which Christianity, whose "field is the world," rose out of Judaism, the special cult of a

privileged race—we have a parallel in the historical evolution of Buddhism, as a religion of pure humanity aspiring to universality, out of the narrow exclusiveness of Brahmanism with its rigorous politico-ethnological system of hereditary caste.

If, however, we go back to an earlier period, we meet with a most striking example of the workings of these conflicting forces in the disintegration and reconstruction of old Aryan society, thirty centuries ago, in the highlands of Bactria. The nature of this epoch-making movement, which took place as the result of Zarathustra's teachings and under his leadership, and the deep and enduring enmity it excited between people of the same blood, are perceptible in the solemn pledge or confession of faith by which the proselyte was received into the fellowship of the Iranian community.

This remarkable document, written in the ancient Gatha dialect, which is surmised to have been the vernacular of Zarathustra's native province and the mother-tongue of the prophet, begins with an abjuration of the ancestral deva worship and a vow of devotion to the glorious and munificent Ahuramazda, and then proceeds to a renunciation of all evil works, and especially of those deeds of violence peculiar to nomadic freebooters: "I choose the beneficent Armaiti (earth), the good. May she be mine! I detest all fraud and injury done to the spirit of the earth, and all damage and destruction to the homes of the Mazdayasnians. I permit the good spirits, which dwell on the earth in the form of good animals (such as sheep and kine), to roam undisturbed according to their pleasure. I praise, besides, all offerings and prayers to promote the growth of life. I will never do harm or hurt to the habitations of the Mazdayasnians, neither with my body nor with my soul. I forsake the devas, the wicked and malicious workers of iniquity, the most baneful, most malignant, and basest of beings. I forsake the devas and their like, the wizards and their allies, and all creatures whatsoever of such kind. I forsake them in thought, in word, and in deed. I forsake them hereby publicly, and declare that all their deceits and lies shall be put away." After further asseverations in the same strain, and after renouncing anew the devas, and entering into covenant with the waters, the woods, and the living spirit of Nature, and accepting the creed of the fire-priests, the diffusers of light and of truth, the convert concludes by avowing himself to be a disciple of Zarathustra, an adherent of the pure Ahuryan religion, and a member of the righteous brotherhood. Henceforth he is a sworn foe of the evil-doing, ancestral deities, and a zealous co-worker with Ahuramazda in promoting good thoughts, good words, and good deeds—*humata, hûkhta, hvarshta.*

With this proclamation of a purer religion the promulgation

of a higher law of social life and a superior form of civilization was genetically connected—namely, the sacred duty of fostering and gladdening the spirit of the earth (personified as the goddess or angel Armaiti), by tilling the soil and making it fruitful. Husbandry is holiness to the Lord. In the third *fargard* of the Vendidâd this conception of agriculture as a sacred calling is particularly enlarged upon and enforced. The earth is there compared to a beautiful woman, who fails to fulfill her noblest functions so long as she remains virgin and barren. "He who cultivates barley cultivates righteousness, and extends the Mazdayasnian religion as much as though he resisted a thousand demons, made a thousand offerings, or recited a thousand prayers." Indeed, the best way to fight evil spirits is to redeem the waste places which they are supposed to inhabit. The spade and the plow are more effective than magic spells and incantations as means of exorcism. An old Avestan verse, which is quoted in inculcation and encouragement of tillage, and may have been sung by Iranian husbandmen as they sowed the seed and reaped the harvest, celebrates the influence and efficacy of their toil in discomfiting and driving out devils:

> "The demons hiss when the barley's green,
> The demons moan at the thrashing's sound;
> The demons roar as the grist is ground,
> The demons flee when the flour is seen."

[These lines have also in the original a sort of rude rhyme or assonance peculiar to ancient poetry:

> "Yadh yavô dayât âat daêva gis'en,
> Yadh s'udhus dayât âat daêva tus'en;
> Yadh pistro dayât âat daêva urathen,
> Yadh gundô dayât âat daêva perethen."
>
> Vendidâd, iii, 105–108, Spiegel's ed.]

If the Mazdayasnian religion, as revealed in the Avesta, illustrated in a remarkable manner the Benedictine maxim *laborare est orare*, it had no sympathy with the melancholy salutation *memento mori*, with which the Trappist greets the members of his silent brotherhood. As taught by the Iranian prophet and still practiced by the modern Parsis, it is pre-eminently a religion of thrift, and enjoins as a sacred duty the honest accumulation and hearty enjoyment of wealth. Poverty and asceticism have no place in its list of virtues. Voluntary abstinence from the pleasurable things of the good creation is an act of base ingratitude and treason toward the bountiful giver of them. He who despises them is a contemner of Ahuramazda and an ally of the devas, and contributes thus far to the triumph of evil in the world. The righteous man should not dwell upon the idea of

death, but banish it from his thoughts and earnestly strive after the realization of a fuller and richer life. It is the height of folly to suppose that mortifications of the flesh can further spiritual growth. Whatever fosters the health of the body favors the health of the soul; but the emaciation of the body impoverishes the soul. The notion which underlies what is known as "muscular Christianity" pervades the entire Avesta and finds a naïve and pithy expression in the following text of the Vendidâd, which the tiller of the soil is directed always to bear in mind and frequently to repeat:

"Who eateth not for naught hath strength,
No strength for robust purity,
No strength for robust husbandry,
No strength for getting robust sons."

[Here, too, we have a bit of old poetry passed into a proverb. In the original the only trace of rhyme (and this we have preserved in the rendering) is the assonance of the second and third lines:

"Naêchis aquarentam tva,
Nôit ughrâm ashyãm,
Nôit ughrâm vas'tryãm,
Nôit ughrâm putrôistêm."

Vendidâd, iii, 112–115.

The editorial bracketing of the last line by Prof. Spiegel, as a possible interpolation, indicates an excess of critical suspicion, since this line not only fills out the verse, but also finishes up the thought, rounding and completing the expression of the sentiment with a climax.]

In another passage Ahuramazda declares: "Verily I say unto thee, O Spitama Zarathustra! the man who has a wife is far above him who begets no sons; he who has a household is far above him who has none; he who has children is far above the childless man; he who has riches is far above him who is destitute of them. And of two men, the one who fills himself with meat is filled with the good spirit (*vôhu manô*) much more than he who goes hungry; the latter is all but dead; the former is above him by the worth of a kid (*as'perena*), by the worth of a sheep, by the worth of an ox, by the worth of a man. [*As'perena*, usually rendered weight or coin, is derived from $a + s'par$, and means not walking or not grown, a young animal, a kid or a lamb. Cf. Sanskrit *sphar* or *sphur*, to expand or to swell.] Such a person can resist the onsets of As'tôvîdhôtus (the demon of death); can resist the self-moving arrow; can resist the winter fiend, even though thinly clad; can resist and smite the wicked tyrant; can resist the assaults of the ungodly Ashemaogho (the destroyer of purity) who does not eat." (Vend. iv, 130–141.)

According to Herodotus (i, 136), the Persian king gave prizes to those of his subjects who had the greatest number of children. Vigorous procreation was one of the most effectual means of grace. It is stated in the Sad-dar that "to him who has no child, the Chinvad bridge (leading to paradise) shall be barred. The first question the angels who guard this narrow passage will ask him is whether he has left in this world a likeness of himself; if he answers in the negative, they will leave him standing at the head of the bridge, full of sorrow and despair." In the same work that contains this piece of eschatology it is also written: "There are those who strive to pass a day without eating and who abstain from meat; we, too, have our strivings and abstainings, namely, from evil thoughts, and evil words, and evil deeds. Other religions prescribe fasting from bread; ours enjoins fasting from sin."

The Brahmans maintained that the man who died without a son went to perdition, because there was no one to pay him the traditional family worship; hence the necessity of adopting a son in case he had none of his own. The Levitical law, as we have already seen, compelled a man to take the wife of a deceased brother, who died childless, and raise up seed to him. In the Persian Rivâyats, or collections of traditions, similar matrimonial prescriptions are given. Thus, if a man over fifteen years of age dies childless and unmarried, his relations are to provide a maiden with a dowry and marry her to another man. Half of the children resulting from this union are to belong to the dead man and half of them to his proxy, the actual husband, and she herself is to be the dead man's wife in the next world. This kind of wife is called *satar*, "adopted." Again, if a widow, who has no children by her first husband, marries again, half of her children by the second husband are regarded as belonging to the first husband, and she also belongs to him in the future life; such a wife is called *chakar*, "serving." The first child of an only daughter belongs to her parents, if they have no sons, and they give her one third of their property in compensation. This kind of wife is called *yukan*, or "only child" wife. (Dr. E. W. West, Pahlavi Texts, in The Sacred Books of the East, vol. v, p. 143.) All these laws and customs show the vital importance attached to the possession of male offspring and to the preservation of an unbroken succession in the line of descent.

There are strong indications that the transition from pastoral to agricultural life in old Aryan society preceded the transformation of religious conceptions, and that the latter grew up gradually as a means of concentrating and more completely consolidating the former. In the second *fargard* of the Vendidâd a curious account is given of Yima, who lived before Zarathustra and is

spoken of as a king rich in herds and a man of renown in Airyana-Vaêjô, the Eden of the race. It was this exalted personage whom Ahuramazda is said to have first chosen to be the promulgator of the true faith. But Yima, the son of Vîvanghañt (a name derived perhaps from *vangh*, to dwell or abide, and meaning settler or dweller in fixed habitations), excused himself, on the plea of unfitness for the prophetic office. He may have been, like Moses, a man of deeds rather than of words, "slow of speech and of a slow tongue." Then said Ahuramazda, "If thou wilt not be the bearer and herald of the faith, then shalt thou inclose my habitations and become the protector and preserver of my settlements." Thereupon he gave him a golden plowshare and a goad decorated with gold as insignia of his royal office. [The word *s'ufra* I prefer to translate "plowshare" rather than "sword" with Haug, or "lance" with Spiegel. It means literally a *cutting* instrument. In the Avesta, plowing is called "cutting the cow"; and in the Vedic hymns the phrase "cut the cow" is equivalent to "make fertile the earth." "The soul of the cow" (*gêush urvâ*) means the spirit of the earth or the animating energy of Nature. In the Pahlavi translation of this passage *s'ufra* is rendered by *sûlâk-homand*, "having holes" or "sieve," and might therefore correspond to the Sanskrit *s'ûrpa*, "winnowing tray." The Pahlavi for plowshare is *sûlak*, and the close resemblance of this word to *sûlâk*, "hole," modern Persian *sûlâkh* and *sûrâkh*, may have led to a confusion and interchange of terms, both of which involve the idea of piercing or perforating.]

And Yima bore sway three hundred years; and the land "was filled with cattle, oxen, men, dogs, birds, and red blazing fires," until there was no more room for them therein. Then Yima went southward (literally, "toward the stars on the noonday path of the sun"), and, invoking the bounteous Armaiti, touched the earth with the golden plowshare and pierced it with the goad; and, in obedience to his behest, the earth expanded and became one third larger than before. This process he repeated, according to the Zand, after six hundred years and again after nine hundred years, with a constantly increasing extension of the earth, which finally became about thrice its original size, and thus afforded ample space for men and kine.

It is not difficult to discover the meaning of this legend. It is the mythical statement of the effect of agriculture in practically enlarging the surface of the earth by increasing its capacity for supporting animal life, and thus rendering it possible for a greater number of persons to subsist on the products of the same area of soil. A tract of country which would furnish precarious food for a single hunter, or pasturage for a score of herdsmen, would, even under rude tillage, easily supply sustenance for a

hundred husbandmen. Indeed, it has been estimated that one acre of arable land will bring forth as much food and consequently sustain as many inhabitants as two thousand acres of hunting ground.

In the fullness of time Yima was succeeded by the man who, like Aaron, could "speak well," and in the first Gâtha we find an address which Zarathustra delivered to his countrymen congregated around the sacred fire. It begins as follows: "I will now reveal to you who are here assembled the wise words of Mazda, the worship of Ahura, the hymns in praise of the good spirit, the sublime truth, which I see rising out of the sacred flames." He then appeals to them as the "offspring of renowned ancestors" to rouse their minds and give heed to his divine message: "To-day, O men and women, you should choose your creed."

After this brief exordium, he plunges at once into his subject and offers his solution of the old and ever-puzzling problem of good and evil, which he personifies as twin spirits, counter-workers in the creation of the world, each exercising its peculiar activity and contributing its characteristic element, and promoting respectively the happiness and the misery of mankind. It may also be safely asserted that, from a theistic point of view, no more logical and satisfactory solution of the difficulty has ever been presented. He earnestly exhorts his hearers to follow after the good and to eschew the evil. "Choose between these two spirits, for ye can not serve both." "Be pure and not vile." "Let us be such as help the life of the future." "Obey, therefore, the commandments which Mazda has proclaimed and enjoined upon mankind; for they are a snare and perdition to liars, but prosperity to the believer in the truth and the source of all bliss."

The whole aim of this discourse, of which these extracts suffice to indicate the drift, is to persuade his hearers to renounce or to confirm them in their renunciation of the old Aryan polytheism and worship of the devas, as we find it in the Vedas, and to adopt monotheism or the adoration of the one great and good but by no means omnipotent being, Ahuramazda. As a philosophical system, his doctrine was dualistic and recognized the existence of two original and independent principles in the universe; as a cult, it was monotheolatrous and worshiped only one of these powers.

It may be added that long before the close of the Vedic period the Indo-Aryans had also begun to devote themselves to husbandry, although their chief wealth still consisted in herds. The burden of their hymns and prayers to the gods is for much cattle and a large family of vigorous sons. The foes which they now had mostly to contend with were the Dasyus or aborigines of

India. The occasional mention of Aryan enemies may be partly reminiscences or records of an earlier time and partly references to intertribal warfares, of which there was evidently no lack. It must be borne in mind that all the Vedic hymns appear to have been composed in northern India, and principally in the region now known as the Panjâb. In none of these poetical productions do we find any distinct remembrance of a trans-Himalayan origin or any definite allusion to a former residence outside of India. This circumstance proves that at the time of the supposed migration from the North the ancestors of the Indo-Aryans must have been rude barbarians, destitute not only of written records, but also of the ability to preserve and transmit from generation to generation traditions of great events in their own tribal or national history. The savage has a short memory for whatever lies beyond the sphere of his individual experience.

One of Zarathustra's chief injunctions was to "listen to the soul of the earth," and to "succor and foster the life of Nature." This is to be done by cultivating and fertilizing the soil; since the increase of its productivity augments the sum of vitality in the world and contributes to the ascendency of the *vohumanô* or good mind, synonymous with *vis vitalis* or living force, and aids in securing the supremacy of Ahuramazda. Instead of bowing down in servile fear before the phenomena of Nature, the Mazdayasnians are directed to revere and cherish her kindly and beneficent spirit, so that "the wilderness and the solitary place shall be glad for them, and the desert shall rejoice and blossom as the rose."

Angrô-Mainyush and his satellites, the devas, on the other hand, are constantly striving to resist and to thwart this purpose and to keep the earth in her native state of virginal wildness and ruggedness by investing her with the dread sanctities and superstitions of a crude polytheistic physiolatry, by assaulting and ravaging the cultivated settlements of the Ahuryan agriculturists, and by fomenting and fostering the spirit of primeval savagery, personified as *Akemmanô*, or the evil mind. In the sacred books and traditions of both factions, and more especially in those of the reformatory party, are frequent traces of this social rupture and religious schism, and of the deadly hostility naturally existing between nomadic hordes, that still adhere to a life of pasturage and pillage, and men of more advanced ideas, who dwell in fixed habitations (*gaêthas*) and devote themselves to husbandry.

I am well aware that M. James Darmesteter and other representatives of what might be called the meteorological school of Avestan scholars deny the historical reality of a religious schism of the kind here described, and would reduce Zarathustra and all

the incidents of his life to a series of solar myths. It is, however, only on the theory of a religious schism that the fact that the deities of Brahmanism are the devils of Zoroastrianism, and *vice versa*, can be adequately explained. To assert that this antagonism is the result of an "accidental selection" of gods is no explanation at all. The religious history of mankind is not a record of casualties or mere chapter of accidents.

Besides, we have a modern example of a similar enmity growing out of the transition from nomadic to sedentary life in the mythology of the Dards, who are, perhaps, one of the oldest races and most primitive peoples of the East, and who believe in the existence of demons called *yatsh* (bad), which, like the Homeric Cyclops (the barbarous aborigines of the Sicilian coast), are of gigantic stature, and have only one eye, set in the middle of their forehead. These demons haunt the mountains and the wilderness, and are exceedingly hostile to agriculturists, whom they vex and harm in every possible manner, stealing and destroying the crops, and even carrying off the husbandmen to their gloomy caverns. In this scrap of mythology we have the survival of the old strife between barbarism and civilization, which began with man's first efforts to improve his condition.

The barbarian is, in fact, the most uncompromising incarnation and typical representative of conservatism; and it is the survival of the barbarian temper of mind that constantly hampers progress and hinders reform in modern times. His daily life is the dullest routine and would be unbearable, were it not the outcome and expression of the general rigidity and sterility of his intellect. He treads religiously in the footsteps of his forefathers, generation after generation, the whole mass moving on bodily and mentally in single file, as is the custom with savages. He is the stubborn foe of all innovations, and punishes as treason against the tribe every deviation from the beaten trail. Under such circumstances no social transformation can be effected without fierce battle and bloodshed. In the primitive history of mankind, as in the early physical history of the globe, great changes are uniformly the result of great convulsions.

It is not merely the love of booty that leads nomadic tribes to attack and lay waste the permanent settlements of husbandmen, but the instinct of self-preservation resisting the encroachments of a new form of social organization which imperils the old. For this reason hunters are hostile to herdsmen, and herdsmen to tillers of the soil; since pasturage diminishes the extent and value of hunting grounds, and agriculture diminishes the area of pasturage.

Mr. D. Mackenzie Wallace gives a striking illustration of this antagonism in the history of the Cossacks of the Don, who, so

long as they lived by sheep-farming and marauding, prohibited agriculture under pain of death. This severe interdict of a peaceful pursuit originated, not as some have supposed in the desire to foster the warlike spirit of the people, but rather in a perception of the fact that "the man who plowed up a bit of land infringed thereby on his neighbor's right of pasturage." By this act he became in a certain sense guilty of treason against pastoral society, the very foundations of which, the green sod, he broke up and destroyed with his plowshare. He not only restricted and reduced the actual area of grazing, but also struck a blow at the life of a cattle-rearing community. The practical workings of this crude and clannish conception of patriotism are recorded, as Mr. Wallace observes, on the pages of Byzantine annalists and old Russian chroniclers, who describe the periodical havoc of farmsteads committed by the nomadic tribes which from time immemorial had roamed the vast plains north of the Black and Caspian Seas, razing the houses, ravaging the fields, and leaving the bodies of the husbandmen as food for vultures.

The roving Bedouins, dwellers in the desert, as their name implies, despise the cultivators of the soil and call them contemptuously *fellahin* (plowers, boors); and their kinsmen the Anasis (*anâsî*, men) hover on the borders and levy blackmail on the villages of Syria. It is also significant for the persistency of this primitive point of view that the Arabic word for agriculture (*falâhat*), should also mean "fraudulent traffic," as though the permanent possession of a piece of land and the exclusive use or sale of the products of the soil were in themselves swindling operations.

These facts of to-day suffice to show the kind of opposition which Zarathustra had to face in his efforts to establish the Iranians in fixed settlements and to accustom them to the acquisition and proper utilization of landed property. In order to accomplish this purpose it was necessary to teach the holiness of husbandry and to invest seedtime and harvest with the sanctity of religion.

The Mormons, after their migration to Salt Lake, where the very existence of the community depended upon converting the desert into a garden, inaugurated the same policy, declaring through the mouth of their prophet that the human race could be redeemed and paradise regained only by means of tillage and making agriculture a sacred vocation and the pursuit of it a prominent part of their creed.

The priests of the old deva cult, the progenitors of the Brahmans, on the other hand denounced Zarathustra as a schismatic and a renegade, a contemner of the gods and blasphemer, a scorner of ancient custom and subverter of social order. They therefore opposed the innovation and fought for the faith of their fathers

with such clumsy weapons as they were most skilled in wielding, looting the homesteads, uprooting and trampling down the green blades of wheat and barley, which stood as representatives of the growing heresy, and, with a logic peculiar to theological zealots and ecclesiastical inquisitors in all ages, refuting the new doctrine and resisting the reformatory movement by greater energy and assiduity in the ancient and honorable calling of cattle-lifting.

As we have already seen, the duty of a man to shield and sustain a tribesman against an alien under all circumstances is imperative. Acts of extortion, treachery, or violence, which would be punished by death if committed against a member of the same tribe, are regarded as indifferent or laudable when the injured person is a foreigner. The same tendency to approve or to extenuate the bad conduct of "brethren" enters also more or less into the ethics of communities or collective bodies which are held together by the bond of belief.

All people in a low state of civilization have a strong prejudice against lending money on interest, and look upon all such transactions as sinful. The same notion still prevails among the lower classes of civilized nations, whose superstitions are in most cases mere survivals of savage life. So strong is this feeling, inculcated and consecrated by religious teachings and traditions, that a certain stigma attaches to the money broker even in the minds of otherwise intelligent persons. "Many lend money on interest," says Cato, "but it is not honorable to do so. Our ancestors enacted in their laws that the thief should restore twofold, but the taker of interest fourfold, from which we see how much worse a usurer was thought to be than a thief."

In general, however, usury, like every other supposed crime, was regarded as wrong only when applied to kindred or tribesmen. The Jews were forbidden to "take a breed of barren metal" from those of their own faith, but might exact it from Gentiles. Curiously enough, in the middle ages this privilege was granted to the Jews, not in the spirit of favoritism, but as a necessity to sovereigns and to society and from feelings of utter scorn and contempt. As neither government nor trade could do without this vilely esteemed vocation, the Jews were selected to carry it on, because they were considered a vile people incapable alike of improvement or of deeper degradation. The state and the Church, which felt an interest in the spiritual welfare and safety of the Christian, were wholly indifferent to the future fate of the Jew. That sweet saint, Bernard of Clairvaux, surnamed the honey-flowing teacher (*doctor mellifluus*), urged the rulers of his day to tolerate the Jews, not because he hated persecution, but in order that Christians might not be constrained to imperil the salvation of their souls by the sin of usury. The Israelitic pariahs of me-

diæval society rendered the same service to Christian virtue that professional prostitutes do to female chastity. We have a striking illustration of this point of view in a decree issued in 1219, by the German emperor Frederick III, permitting the Jews to dwell in Nuremberg and to take a percentage for the use of money. Inasmuch as this business, he said in justification of his edict, is essential to the growth of commerce and the prosperity of the city, it will be a lesser evil and wrong for Jews to practice usury than for Christians, since the former are a stubborn and stiffnecked race, and, if they persist in their perversity, as they probably will do, are doomed to be damned anyhow.*

The Hebrew, on the other hand, heartily reciprocated the Christian's contumely, and could hardly conceal, under the prudent disguise of mock humility, his disdain for the upstart Nazarene. He not only deemed it a religious duty to cheat him in money matters, but thought it perfectly right to use him as an agent in base or criminal transactions which a good Israelite could not conscientiously perform.

This mental and moral attitude, which even the modern Hebrew still maintains, is strikingly exemplified by the following incident: Between 1820 and 1830 a band of burglars, numbering over one hundred persons and consisting entirely of Jews, made property so unsafe as to create a panic among the inhabitants of the Prussian provinces of Posen and Brandenburg. The chief of the band was a certain Loewenthal in Berlin, and all the members of it were extremely devout attendants of the synagogue and strict observers of every jot and tittle of the Levitical law. They never broke into the houses of Jews and never stole on the Sabbath, since such an act would be a desecration of the sacred "day of rest"; but, rather than let an exceptionally favorable opportunity escape, they sometimes employed a so-called *schabbesgoï* [*schabbesgoï* (Sabbath-Gentile) is a Jew-German term for the Christian attendant or servant who does for an Israelite on the Sabbath the things which his religion forbids him to do for himself] to commit the crime for them, and, if necessary, did not hesitate to have some one of their own number accompany him on his burglarious expedition a couple of thousand yards or so, the limits of a Sabbath day's journey. In case one of the band was suspected of any particular offense and arrested, the surest and speediest way of clearing himself was to prove an *alibi* by the testimony of two witnesses, as the law required. But the pious Hebrew regards perjury with peculiar abhorrence, and fears above all things to take a false oath. Shylock was

* [We have referred to this characteristic decree in The Popular Science Monthly for December, 1891, p. 176, in illustration of another subject.]

eager to cut the heart out of his hated enemy, but he would not lay perjury upon his soul—no, not for Venice! The burglars kept, therefore, in their pay two Christians, who were as ready to forswear themselves as any Tammany Hall politician at the polls, and who made the requisite false oaths at fixed rates.

These examples serve to show the natural tendency of mankind to look upon compatriots and coreligionists from a different moral standpoint from that with which they regard persons who are not connected with them by such ties, and to whom they not only attribute a lower standard of right and wrong, but also act upon it as a rule of conduct in dealing with them.

Great dissimilarity in physical characteristics intensifies the ethical estrangement caused by differences of blood and of belief. The more any tribes of men deviate from ourselves in form and feature, the less we are inclined to think of them as endowed with the same powers and passions, the same kind of sympathy and sensibility as ourselves, or as entitled to the same rights that we possess. A people with black skin, woolly hair, flat noses, and countenances of a strongly prognathous character do not enlist our kindly feelings and awaken our affections in the same manner and degree as representatives of a fair-complexioned and finely featured type would do. The schemes of European governments and of private individuals and corporations for the exploration, partition, and colonization of Africa are based upon the assumption that the Africans themselves have no claim to the continent which they inhabit. The only African colony that has ever been founded on principles of common justice and with a full recognition of the rights of the natives is the Republic of Liberia, established more than sixty years ago under the auspices of the United States, and this was done solely for the sake of getting rid of an undesirable population of free negroes at home. All the other enterprises of this sort are morally and legally no better than buccaneering expeditions.

The ethical maxims which we are wont to accept as axiomatic in our mutual relations as civilized individuals and nations are too easily set aside as inconvenient and inapplicable to our dealings with the so-called lower races. The fatal facility with which under such circumstances enlightened Europeans of the nineteenth century may revert to primitive savagery as soon as the outward restraints of civilization are removed is seen in the early settlers of Australia, who did not scruple to shoot the defenseless and harmless aborigines as they would any game, and feed the carcasses to their hounds. The inoffensive and rather feeble-bodied Negritos were treated as beasts of venery, which could be hunted without danger and furnished plentiful supplies of dog's meat, costing the sportsman nothing, not even a pang of

conscience, only the price of a cartridge. (Cf. Schaafhausen, in The Anthropological Review, London, 1869, p. 368.)

More recent and even more revolting exemplifications of this tendency to relapse in barbarism are the atrocities committed by Major Barttelot, and the conduct of Mr. Jameson, of Stanley's Emin-Relief Expedition, who purchased a young negro girl and gave her to a horde of cannibals in order to make sketches from life of the manner in which she was torn in pieces and devoured.

There are also instances on record of Englishmen, Dutchmen, and Frenchmen who in their warfare with Indians adopted from their savage foes the custom of scalping and torturing their captives. In fact, as Waitz has shown in his Anthropolgy (iii, 174), there is scarcely a vice of barbarous tribes which Europeans when removed from the restrains of civilization have not practiced. In the South Sea islands they have in some cases become anthropophagous.

Here we are suddenly brought face to face with the depressing fact that men, who are heirs to ages of intellectual culture and armed with all the powers and possibilities of good and evil which modern science has put into their hands, yet relapse morally to the level of rude cave dwellers and contemporaries of the mammoth in making their superiority of mental endowment and material equipment minister to deeds and passions worthy of the lowest stage of barbarism.

All emigration to wild regions is, in a greater or less degree, atavistic in its effects, and, by loosening or removing the many leading strings of association by which the average man is kept in an upright position and a straightforward course, lets him fall back and retrograde, and thus tends to bring him nearer to his flint-chipping neolithic ancestor. It throws each individual upon his own ethical resources by releasing him from the constant though hardly conscious social pressure of an environment which is the resultant of long periods of human progress, and by which alone the masses of so-called civilized nations are prevented from relapsing into the original condition of the race.

Happily, however, such extreme cases of moral reversion as those of the early emigrants to Australia and the recent explorers of Africa are only sporadic, and the ubiquity of humane and enlightened public opinion arising from greater frequency and rapidity of international intercourse, and causing its immediate influence to be felt in the remotest and roughest border lands of savage and civilized life, will render them still rarer in the future. The telegraph and the telephone are making it daily more difficult and will eventually make it impossible for the most pushing pioneer wholly to lose communication with the advancing body of organized forces behind him, or to break away from

the control of that community of impulses and purposes, and that consensus of moral ideas and perceptions, which we call public conscience. This influence is beginning to penetrate even the darkest regions of Central Africa and to protect the unknown barbaric tribes against the ravages of Arab slave traders and the arbitrary authority of European adventurers. Each nation that joins in this combined movement is doubtless seeking, first of all, to further its own commercial and colonial interests; but it suffices as an illustration of the prevailing spirit of the age that the basis on which they profess to unite is the broad principle of a common humanity.

THE SLEEP OF MOLLUSKS.

By CHARLES T. SIMPSON.

IT is probable that the sleep or dormant period which mollusks share in common with many other organic beings is brought on not merely by the exigencies of climate, but that it is more or less necessary in building up the wasting physical powers. All organized beings seem to require rest in some form or other. If plants, whether from the tropics or temperate regions, are kept in hothouses, they will not grow the year round, and when forced to do so soon become sickly or die outright.

With the mollusks this sleep in many cases may be prolonged indefinitely, often without the slightest apparent damage, and under some conditions which seem really astonishing.

In the sea the clams (*Venus* and *Mya*) have rest periods, during which they sink more deeply into the mud and retreat from the fisherman; the tritons, murices, and ranellas form a shelly growth and mark their seasons of repose by a thickening of the aperture called a *varix*, which is sometimes guarded by spines or knobs. The littorinas, which are amphibious, pass most of their time on grass or sedges at the edge of the sea in the colder regions and high aloft on mangrove or other trees in the tropics, only occasionally going into the water to moisten themselves. Tryon tells of some West Indian species which survived over a year in his cabinet, and of others that lived for months in the dry air of Philadelphia, though they exhibited but little activity; and the writer has kept specimens of the nearly allied *Tectarius* alive in his collection for nearly two years.

Most of the fresh-water species of mollusks pass a period of hibernation in cold climates or æstivation in the tropics, and many of them are wonderfully tenacious of life when withdrawn from the water. In June, 1850, a living pond mussel was sent to Dr. Gray from Australia which had been kept out of water more

than a year, and instances of the survival of unios without moisture for long periods are not rare. While living in south Florida I discovered a colony of unios in a small drain that ran through the pine woods and which only contained water during the rainy season—some three months in the year. Thousands of these mussels were found in the channel among bulrushes, buried vertically an inch or so below the surface in nearly dry soil, with the anterior end downward, and the slightly moist, sandy banks in many places were full of them. The colony extended some ten or a dozen yards along this drain; not a specimen could be found either above or below this space, and the species was not found in the little stream into which it emptied.

A lot of these unios were taken home and laid in the garden, where they remained more than three months wholly unprotected from the hot autumn sunlight during the dry season, and when opened a number of them were found to be alive. Yet ordinarily the want of water causes the *Unionidæ* to speedily die. The summer of 1886 was one of the least rainfall ever known in the upper Mississippi Valley, and many streams and ponds went dry that had never been known to be so before. At this time I collected in northern Illinois and Iowa, and in every instance where the water had evaporated I found the mussels dying by thousands, though in many cases the mud was too soft to bear the collector. While collecting in the Indian Territory I visited a large pond near McAllister that had just been drained, and, although the water stood everywhere in pools, yet the *Unionidæ* were apparently all dead and gaping open, and the stench was so horrible that the struggle between duty and comfort was a severe one. For years I have watched the dredging operations in the Potomac at the capital, as the mud was thrown out on the flats, and in every case the mussels were dead before it was firm enough to be trodden on.

I do not believe in building a theory on too slight a foundation of fact, but I am of the opinion that these unios which have been kept dormant for lengthened periods out of water inhabited streams or ponds that were intermittent. The instance I have given in Florida is a good one, and the mussel Dr. Gray received from Australia is no doubt another. The whole island is noted for heat and long-continued droughts, and with scarcely an exception the streams and lakes go dry during the rainless season. Even the Murray River, the largest stream in the country, and ordinarily navigable for hundreds of miles, sometimes ceases to flow altogether.*

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* Other cases in point are known. In the spring of 1887 I collected several specimens of *Anodonta Ferussacciana* in lagoons along the banks of the South Platte River near

The ampullarias or idol shells, a noble genus of tropical pond snails, bury themselves deeply in mud during the dry seasons. They are remarkable for their ability to live without water, having been kept out of it for years, and they are often brought to foreign countries alive in mahogany logs.

Guilding first noticed that the species of the Antilles had a double system of respiration, which was further dilated on by Caillaud, who brought these snails alive from Egypt; and D'Orbigny discovered that they had a distinct pulmonary apparatus in addition to their gills. According to Joly, anodons and viviparas survive freezing, and will reproduce on being thawed out; and no doubt many of the species that live in cold climates are frozen every winter and resuscitated with the return of spring.

It is believed that all shell-bearing land mollusks either hibernate or æstivate according to conditions of climate. Most of the snails close the aperture with a membranous or coriaceous covering, consisting of lime and mucus, which is called an epiphragm. W. G. Binney has thus described the operation: "The animal being withdrawn into the shell, the collar is brought to a level with the aperture and a quantity of mucus is poured out and covers it. A small quantity of air is then emitted from the respiratory foramen, which detaches the mucus from the surface of the collar and projects it in a convex form like a bubble. At the same moment the animal retreats farther into the shell, leaving a vacuum between itself and the membrane, which is consequently pressed back by the external air to a level with the aperture or even farther, so as to form a concave surface, where, after becoming desiccated and hard, it remains fixed. These operations are nearly simultaneous, and occupy but an instant." As the winter advances the snail withdraws deeper and deeper, shutting itself out by other epiphragms, like a retiring army covering its front by breastworks as it retreats, until sometimes it has made no less than half a dozen, one within the other. With the snails such as ours, that inhabit moist wooded districts, this protecting wall is thin and nearly transparent, while in those of arid regions it is thicker and often calcareous. Some of the large helices of south Europe secrete a somewhat shelly epiphragm resembling the coating of a turtle's egg, convex externally, with the edge turned in and roughly cemented to the aperture of the shell. In this condition, if not resuscitated by moisture, the snails will remain alive for an indefinite period. Woodward tells of a desert snail (*Helix deser-*

Brule, Nebraska, the stream at that time being at an ordinary stage of water. These were kept in a dry shed some two weeks, and the shells became badly cracked by the dry air, yet at the end of that time when opened they were alive. In summer the river becomes so dry that the sand from its bed is blown about the adjoining country.

torum) which, after being glued to a tablet for four years in the British Museum, was noticed to have discolored the paper of its label, and on being put into warm water it revived; and Dr. Stearns kept a *Helix Vietchi* from Cerros Island, Lower California, alive six years without food.* Many other such cases are known.

Strangely enough, the slugs undergo no such period of hibernation, as they only cease activity in temperate climates during the coldest weather, and when a warm spell occurs in winter they are thawed out into new life. It is indeed curious that these naked fellows should be so much more hardy than their relatives, who wear their great overcoats of shells into which they can wholly retreat, but so it is. *Binneya*, a Mexican snail, whose shell is not large enough to cover its body, attaches itself to a spot where it æstivates and forms a parchmentlike epiphragm from the edges of the shell to the place of attachment, and when it returns to activity often carries with it this queer addition to its house. Most snails dissolve this when they awaken from their long sleep.

Nature has kindly relieved the operculated land snails from the trouble of making this protection, and when the time for retiring arrives they simply retreat into the shell and close the door behind them. In this condition they are "not at home" to any callers. The long winter's sleep proves disastrous to many of the snails, and in the spring quantities of dead shells will be found huddled together in hollow trees, under rocks, and in their crevices, or buried beneath the leaves and ground with a few survivors among them. Why they thus assemble together to hibernate is difficult to tell, unless it is because "misery loves company."

The succineas are a somewhat amphibious family of air-breathers, and on the approach of winter often crowd together into tussocks of grass or rushes by the edges of streams and ponds. In eastern Colorado and western Nebraska I have counted from two hundred and fifty to three hundred of them thus tucked snugly away in a single tuft of grass. It is indeed fortunate for them that they are wrapped in unconsciousness during the dreary winter of that shelterless, desolate country, with its howling blizzards and snows drifted wildly over the prairies, and it is marvelous that so large a proportion survives. In that dry region water is a luxury that even a fresh-water snail can not always afford; hence their shells are found strewed over the highest table lands, miles horizontally and hundreds of feet vertically from moisture; and I have gathered numbers of them in

* For an account of this, see a paper On the Vitality of Certain Land Mollusks, by R. E. C. Stearns, Proceedings California Academy of Sciences, October 18, 1875.

winter under projecting rocks high upon the bluffs of the South Platte River.

In the tropics the process of æstivation is analogous to hibernation, but there is not so complete a cessation of the functions. The same epiphragm is made, and the rest is taken for the same purpose—to avoid the vicissitudes of climate; only in this case it is to escape drought instead of cold. And sometimes the same gregarious habit is observed, and the snails crowd in closer than the occupants of a cheap lodging house. On some of the west Florida keys I have seen *Helix Carpenteriana* æstivating under grass and logs in such vast numbers that one might scoop them up by the quart; and in the Maritime Alps I have found other species of the land snails piled together by hundreds in hollows of limestone cliffs during the dry season. The strophias either cling to the stems of low bushes or lie at their roots, as do many species of *Bulimulus*, often in great numbers.

The arboreal species firmly attach themselves to the bark of the trees on which they live and on whose foliage they subsist, and form a solid epiphragm of the consistence of sole leather.* On the lower part of Florida and on the keys the magnificent *Orthalicus* and *Liguus*, the latter gaudy with bands of yellow, brown, and green, the former a soft cream color, with markings of jet black and brown, live often on such trees as the Jamaica dogwood (*Piscidia erythrina*) and the *Bursera*, which shed wholly or in part their leaves during late winter and spring, the dry season. The sight of one of these trees without foliage, and loaded with this strange, glittering fruit, is enough to thrill the heart and stir the blood of any collector, and I shall never forget my first experience with them at Cape Sable. In my eagerness to possess the beautiful things I broke several specimens, as the epiphragm adhered so firmly that the shell crushed before it would loosen, and I could only save them by cutting away the bark.

One wonders why these snails so freely expose themselves during æstivation, when they are utterly powerless to escape from their enemies. Many of these trees, which were full of them, were isolated more or less and were without foliage, and every shell could be seen hundreds of feet away. That they have enemies I discovered afterward as I wandered broken-hearted among the thick scrub of Key West to find quantities of fresh broken *Orthalicus* lying on the ground, but not one alive. Many of them appeared as though a hole had been picked in them by birds large enough to get out the snail and utterly ruin the shell. In this case death came swiftly and painlessly, no doubt, while they were

* The epiphragm of *Orthalicus zebra* is admirably figured and described by Fischer and Crosse in Mission Scientifique au Mexique et Amérique Centrale.

wrapped in sleep. Such is the summer repose or æstivation of the tropical tree snails. For months of bright, sunshiny weather they cling motionless, perched aloft on their favorite trees that at once are home and food for them, firmly attached by a leathery epiphragm that neither sun nor rain nor wind, or anything but themselves, can dissolve; and on the coming of the first showers of the rainy season they awaken to new activity and life.

WASTE PRODUCTS: COTTON-SEED OIL.

By FREDERIC G. MATHER.

IT has been stated that if the waste products of the world had been saved they would sustain the present population for more than a hundred years. Foreign countries give more attention than America to saving the waste. But as the population of the United States increases, and as processes of manufacture are developed, discoveries are made which turn the waste of former products into useful articles of commerce. Glycerin, wood acid, crude petroleum, and even the fine dust from anthracite coal have an importance to-day that they did not have formerly.

Cotton-seed oil is a most conspicuous instance of an article once thrown aside as a nuisance. Originally it was only a by-product in the manufacture of meal from the seed; and even after it was discovered that meal could be made, it was a question what should be done with the oil.

That question has been answered in various ways. What was garbage in 1860 was a fertilizer in 1870, cattle food in 1880, and table food and many things else, in 1890. A small quantity of the oil is made in England, but it is inferior to the American article because the seed comes from Egypt or India. The American cotton parts with its fiber more readily. The best oil is made from seed belonging to the Southern upland cotton, that from the seaboard having a darker color. The exports are chiefly from New York and New Orleans, and the greater part goes to France, Italy, and the Netherlands. There was a constant increase of exports between 1871 and 1884, when over 6,000,000 gallons, valued at $2,600,000, were exported. Since 1884 the export has rapidly declined, only 2,000,000 gallons, worth $1,300,000, being exported of late years, because the demand in the United States has increased.

Nine tenths of the American product enters into the composition of foods, chiefly for salad and cooking oils and for the making of refined lard. The latter use is the most important of all. Nearly forty years ago the oil was mixed with lard for use in cold

climates so that the stiffening point would be several degrees lower. Lard was also prepared with this oil for the Israelites, whose religion does not permit the use of any product of the hog. The refined lard of to-day is made of refined packer's lard, pure dressed-beef fat, and pure refined cotton-seed oil. The consistence of the beef fat is overcome by the oil. Three fourths of the lard in use to-day contains from ten to twenty-five per cent of the oil, and nearly all of it is sold as oil-lard. It has been attacked by producers of hog lard, but investigations have shown that the new lard is quite as wholesome as the old.

Table oil often bears the brand of olive oil when it is really cotton-seed oil mixed with a small proportion of the olive. Sometimes the oil is taken to France and Italy and mixed there, but more often the mixture is made in this country. So closely is olive oil imitated, both as to taste and color, that only an expert knows the difference. In the earlier days of making cotton-seed oil the white oil brought a higher price than the yellow; but to-day the yellow oil is the more expensive. Cheaper processes of manufacture have lowered the price and encouraged the use of the yellow oil in making a substitute for butter.

Cotton oil ranks next to sperm oil and above lard oil for illuminating purposes, and it may be burned in any lamp used for either. Mixed with petroleum, it increases the freedom of burning; but this requires a change in the wick. As a lubricating oil cotton-seed is useless, because it is half way between the drying and the non-drying. For the same reason it can not be used for paints, for wood filling, or for leather dressing. It has some use as a substitute for vaseline and similar products. The oil enters into the production of laundry and fancy soaps and soaps for woolen mills. The American sardines, properly known as young shad and herring, are put up with this oil, and the use of it extends so far that nearly all the real sardines of Europe are now treated in the same way. The oil forms an emulsion in medicine and a substitute for cod-liver oil. On the market the crude oil is known as either prime, or off quality, or cooking. There are also the white summer, the yellow winter, and the white winter. All these, except the crude, bring an average of about fifty cents a gallon in the wholesale market. After the oil has left the seeds, they become food for stock in the shape of oil cake, while the ashes from the hulls make a fertilizer for root crops.

The first attempt to extract oil from cotton seed was made in Natchez, Miss., in 1834. The machinery of the mill was of the most primitive kind, the pressure being given by wedges. Failure attended this effort, and also an effort in 1852 with improved machinery. In 1855 cotton seed began to have a commercial value. Small mills were established, and the prospects for devel-

oping the industry were good until the breaking out of the civil war cut off the supply of seed. Directly after the war, in 1866, there were only seven mills in the whole country. Three of them were in New Orleans, one in Providence, one in Cincinnati, one in Memphis, and one in New York. In 1870 there were twenty-six mills; in 1880, forty-five; and in 1890, two hundred and twenty-five—all but two being in the Southern States, as follows: Alabama, thirty; Arkansas, twelve; Florida, three; Georgia, thirty-nine; Louisiana, fifteen; Mississippi, twenty-three; North Carolina, twenty; South Carolina, thirty-four; Tennessee, twenty; Texas, twenty-seven. The highest capacity of any of the mills is 320 tons daily; and for all the mills, 7,636 tons daily, or 2,367,160 tons annually. None of them are operated on full time, and most of them run only three or four months during the height of the cotton season. The mills are of all sizes, and they range from $5,000 to over $250,000 in value.

The output of cotton-seed products was valued at $600,000 in 1860, $2,205,000 in 1870, $7,691,000 in 1880, and nearly $22,000,000 in 1890. Since that date the product has fallen off. The details for 1890 were: 28,000,000 gallons of crude oil; 17,000,000 pounds of cotton batting; 283,000 tons of oil cake; 378,000 tons of hulls, ash, soap-stock, and other by products; and $2,853,000 of enhanced value in refining the oil and manufacturing the soap. The Southern States produced 2,870,417 tons of cotton seed in 1880, of which barely one eighth was crushed in the mills. The yield of seed during the past five years has been as high as 3,600,000 tons; but only one fifth of it reached the mills. The American Cotton-seed Oil Company, formerly known as the Cotton Trust, owns the entire capital stock of ninety-five factories, a small portion of which are not in operation. The factories include not only crude-oil mills, but mills for the production of fertilizers, soap, and the other products. The total business for the year ending November 1, 1889, the best in the history of the mills, was about $25,000,000. An improved method of crushing gave better results than for any previous year. At first the oil was transported from the mills in barrels, but now a great saving is effected by the use of tank cars.

When the season is not dry the seed is rich in oil, and it yields readily thirty-five or more gallons to the ton. An unfavorable season reduces the yield to thirty-one gallons. When the seed is well stored and properly ventilated, it will keep for a year; it is liable to become rancid in the hold of a vessel. If stored long in bulk, it becomes superheated and liable to spontaneous combustion. These facts prevent exportation in large quantities. The cotton plant yields an average of nine hundred and fifty pounds of seed to each bale of cotton. The price of seed has been as high

as seventeen dollars a ton, but there is no profit to the millers if they pay much over twelve dollars. A sharp competition among them led to the forming of an association of the mills in 1878, which was the forerunner of the American Cotton-seed Oil Trust. The Southern States are now divided into districts, each one supplying certain mills, and keeping a uniform price for the seed.

The bulk of the supply is obtained from plantations immediately upon the Southern rivers, because the seed can be transported at little cost. The mills are also located upon the rivers. Once landed at the mills, the seed is conveyed in an elevator to a screen, or cylindrical sifter, where it is shaken until it is free from dust and sand. Then it is blown against another screen to remove stones, iron, and other foreign substances that might injure the rollers. A second elevator carries the seed to the loft, where another sifter separates the seed proper from the bolls or outside hulls of the cotton bloom. No matter how close the picking may have been, the bolls still have cotton sticking to them, and they are dropped into a gin to remove the lint. This is known as "crapo cotton," the only variety of linter produced in the mills. The seed having fallen through the screen, is carried along another screen or gutter directly over the gins. They drop through holes in the screen upon the gins; but when the box above the gin is full the hole is closed automatically, and the screen carries the seed forward to the next box, thus keeping all the boxes full. The gins differ from cotton gins in having one hundred saws instead of sixty. The saws are but half an inch apart and the teeth are very firmly set. The problem of wholly removing the lint, save by chemical process, has not yet been solved.

Once thoroughly separated from all foreign substances—dust, bolls, and cotton—the seed is conveyed to the roller, a revolving cylinder containing twenty-four knives and four back knives, which cuts the hulls from the kernels. This process was formerly carried on by grindstones. The hulls go upstairs, where they are again treated to find such kernels as may still be clinging to them, after which they are sold or used as fuel in the furnace of the mill. Only half of them are needed for this purpose, the other half being sold as food for cattle. The ashes of the hulls make an excellent lye for soap or for the refining of the oil. The kernels are conveyed to rollers, where they are crushed very fine. They are thence removed to the heaters, being agitated all the time so as to give an equal exposure and allow the oil to be more readily extracted. The kernels are then placed in woolen bags packed between horse-hair mats, backed with leather, and having a fluted surface inside to allow the oil to escape more freely. The hydraulic pressure, furnished by the oil itself instead

of by water, is from one hundred and fifty to two hundred and fifty tons.

The bags are in the press about fifteen minutes, the oil running out and the dry kernels remaining behind in a solid cake —the oil cake of commerce. This product is of a rich golden color, quite dry, and of a sweet and oily taste. When used for food it is ground to the consistence of corn meal, and it is known as cotton-seed meal. A comparison of the number of pounds of flesh produced by several kinds of food is as follows: Cotton-seed cake, forty-one pounds; bran, thirty-one pounds; peas, twenty-two pounds; corn, twelve pounds; rye, eleven pounds. The number of pounds of fat produced by the several foods are these: Cotton-seed cake, fifty-seven pounds; bran, fifty-four pounds; peas, fifty pounds; corn, sixty-eight pounds; rye, seventy-two pounds; hay, fifty pounds. It is claimed that cotton-seed cake fed to cows gives a rich and plentiful supply of milk.

The oil, having been pumped into the oil room, is treated with caustic soda and constantly stirred. A deposit falls to the bottom of the kettle and the refined oil is turned off. It averages about eighty-two per cent of the crude oil. The deposit, known as soap stock, sells readily to soap manufacturers, or it is used by the mill itself in the manufacture of soap. Much of it is sent to foreign countries. The oil is occasionally refined over again to remove wholly a slightly bitter flavor of the seed which reduces the culinary value.

It will be noticed that the products of the seed are—(1) oil, both the crude and the refined; (2) oil cake; (3) lint; (4) hulls; (5) soap stock; (6) glycerin. One gallon of crude cotton-seed oil will yield three pounds and a half of glycerin, but thus far only a small amount has been made. The use of the seed for these several purposes has been of great benefit to the Southern States. Their output is constantly increasing, while the supply of petroleum in the oil fields of Pennsylvania and elsewhere appears to be decreasing. The world was greatly excited when petroleum was discovered. But the discovery of cotton-seed oil has been so gradual that the importance of it has not been realized until lately. This brief statement of what is being done to-day with an article that was going to waste a generation ago must lead every student of economy to ask, "Are there not other waste products of the present time that will be used a generation hence, and thus not only increase the comfort of living but also decrease the expense?"

ANCIENT AND MEDIÆVAL CHEMISTRY.

By M. P. E. BERTHELOT.

CHEMISTRY is a modern science, constituted hardly a century ago; but its theoretical problems were discussed and its practices put in operation during all the middle ages. The nations of antiquity were already acquainted with them, and their origin is lost in the night of primitive religions and prehistoric civilizations. I have described elsewhere the first rational attempts to explain the chemical transformations of matter, and purpose now to speak of the chemical industries of the ancient world, and their transmission to the Latins of the middle ages. The story is of interest as showing how the cultivation of the sciences has been perpetuated in the material line by the necessities of their adaptations, through the catastrophes of invasions and the ruin of civilization. Only the total extermination of populations, such as was at times practiced by the Mongols and the Tartars, could completely destroy this cultivation. But such horrors as those perpetrated by Tamerlane have been of rare occurrence.

From the most remote times man has applied chemical operations to his necessities, performing them for metallurgy, ceramics, dyeing, painting, the preservation of food, medicine, and the art of war. While gold and sometimes silver and copper existed in the native state, and required only mechanical preparation, lead, tin, iron, and often copper and silver, had to be extracted from their usual minerals by very complicated artifices. The production of alloys necessary for the fabrication of arms, money, and jewels is also an essentially chemical art. The study of the alloys used in goldsmiths' work gave rise to the prejudices and frauds of alchemy, as is proved by the testimony of an Egyptian papyrus preserved in the Leyden Museum, and of the writings of the Grecian alchemists.

The art of preparing cement, pottery, and glass likewise depends on chemical operations. The workmen who dyed cloths, clothing, and tapestries in purple or other colors, an industry practiced first in Egypt and Syria and then in all the Grecian, Roman, and Persian world, not to speak of the extreme East, employed highly developed chemical manipulations; and the cloths found on the mummies and in the sarcophagi attest their perfection. Pliny and Vitruvius describe in detail the production of colors, such as cinnabar or vermilion, minium, red chalk, indigo, black, green, and blue colors, vegetable as well as mineral, performed by painters. The chemistry of alimentation, fruitful in resources and in frauds, was next practiced. The art was known

of accomplishing at will those delicate fermentations which produce bread, wine, and beer, and which modify a large number of foods; also of falsifying wine by the addition of plaster and other ingredients. The art of healing, seeking everywhere for resources against diseases, had learned to transform and fabricate a large number of mineral and vegetable products, such as sugar of poppy, extracts of nightshades, oxide of copper, verdigris, litharge, white lead, the sulphurets of arsenic and arsenious acid; remedies and poisons were composed at the same time, for different purposes, by doctors and magicians. The manufacture of arms and of inflammatory substances—petroleum, sulphur, resins, and bitumens—had already, anciently as well as in our own time, drawn upon the talents of inventors and given rise to formidable applications, especially in the arts of sieges and marine battles, previous to the invention of the Greek fire, which was in its turn the precursor of gunpowder and of our terrible explosive matters.

This rapid review shows how far advanced in the knowledge of chemical industries the Roman world was at the moment when it went to pieces under the blows of the barbarians. But the ruin of the ancient organization came about by degrees: while high scientific study, hardly accessible to coarse minds, ceased to be encouraged, and was gradually abandoned; while the Greek philosophers, knocked about between the religious persecution of the Byzantine emperors and the indifferent disdain of the Persian sovereigns, no longer trained pupils; while the great names of Grecian physics, mathematics, and alchemy hardly passed the time of Justinian, it is still certain that the necessity of professions indispensable to human life, or sought out by sovereigns and priests, could maintain and did maintain effectively most of the chemical industries.

Proofs of various kinds can be brought up in support of these reasonings. Some are drawn from the examination of the monuments, arms, potters' and glass ware, cloths, gems and jewels, and art objects of every kind which have come down to us. Such examination furnishes, in fact, incontestable results, provided the dates of the objects are certain, and they have not suffered restoration. Respecting the date, we can not exercise too much prudence and distrust, whether we are examining buildings or objects in museums. The accounts and descriptions by contemporary historians furnish other data, but less precise, for it is better to have the object in hand than the description. They have the advantage, however, of giving us indications independent of the ulterior progress of the industry. We have a still surer and more exact class of data than the chronicles in the technical treatises and works concerning arts and trades which have come down to us, whenever those treatises have an ascertained

date, even were it only the date of their copies. This source of facts is already known as to antiquity. It is not wanting as to the middle ages, although it seems to have till now escaped the erudite persons who have written the history of science, and it permits us to reconstitute that under a new form and with a new precision. By the aid of those documents I shall attempt to show, concerning myself especially with chemical industries, what knowledge, practical or theoretical, subsisted after the fall of ancient civilization, and how the traditions of the shop maintained those industries, almost without new inventions, but at least at a certain level of perfection.

The history of physical science in antiquity is very imperfectly known to us. There existed then no methodical treatise for the purpose of teaching, such as we have in the principal civilized states. Hence, except as to the medical sciences, we have only insufficient notions respecting the processes employed in the arts and trades of the ancients. The experimental method of the moderns has associated those practices into a body of doctrines, and has shown close relations between them and the theories for which they served as basis and confirmation. This method was almost unknown to the ancients, at best as a general principle of scientific learning. Their industries had little connection with theories, excepting in measures of length, surface, or volume, which were deduced immediately from geometry and in goldsmiths' receipts, which were the origin of the theories, partly real and partly imaginary, of alchemy. It has been even asked if industrial formulas were not formerly preserved by purely oral tradition and carefully held back for the initiated. Some scraps of the traditional lore may have been transcribed into the notes which have been used in the composition of Pliny's Natural History and the works of Vitruvius and Isidore de Seville, not without a considerable mixture of fables and errors. But a more thorough examination of the works that have come down to us from antiquity, a more attentive study of the manuscripts, at first neglected because they did not relate to literary or theological studies or to ordinary historical questions, permits the affirmation that they were not so. We are all the time discovering new and considerable documents which show that the processes of the ancient industrials were then, as now, inscribed in workmen's note-books or manuals intended for the use of the tradespeople, and that they were transmitted from hand to hand from the most remote times of ancient Egypt and Alexandrine Egypt, to those of the Roman Empire and the middle ages. The discovery of these note-books offers all the more interest because the use of the precious metals with civilized peoples goes back to the highest antiquity; the technique of the ancient goldsmiths and jewelers is not revealed to us all at once except

by the examination of the objects that have come down to us. The earliest precise and detailed texts describing their processes are contained in an Egyptian papyrus found at Thebes, and now in the museum at Leyden.

This papyrus is in the Greek language and dates from the third century of the Christian era. In my translation of it, comparing parts of it with phrases in the works of Pliny and Vitruvius on the same subjects and with Greek alchemistic works of the fourth and fifth centuries, I have reconstituted a whole science, ancient alchemy, till now misunderstood and uncomprehended, because it was founded on a mixture of real facts, profound views on the unity of matter, and chimerical religious fancies. These practices and theories had a still larger bearing than the working of metals. The industries of the precious metals were in fact associated at that epoch with those of the dyeing of cloths, the coloring of glasses, and the imitation of precious stones, all guided by the same tinctorial ideas and executed by the same operators.

Thus alchemy and the chimerical hope of making gold were derived from the goldsmiths' artifices for coloring metals. The pretended processes of transmutation which were current during the middle ages were in their origin only tricks for preparing alloys of inferior standard—that is, for imitating and falsifying the precious metals. But, by an almost invincible attraction, the operators addicted to these practices did not hesitate to imagine that one could pass from the imitation of gold to its effective formation—especially if he had the aid of the supernatural powers, invoked by magical formulas.

At any rate, it was not known till now how these practices and theories passed from Egypt, where they were flourishing toward the end of the Roman Empire, into the West, where we find them in full development from the thirteenth and fourteenth centuries in the writings of the Latin alchemists and in the laboratories of the goldsmiths, dyers, and makers of colored glass. Their renascence was generally attributed to translations of Arabian works made at that epoch. But, without assuming to deny the part played by the Arabian books in the renascence of the arts and sciences in the West, in the period of the Crusades, it is no less certain that a continuous tradition subsisted in the professional recollections of the arts and trades from the Roman Empire till the Carlovingian period, and later—a tradition of chemical manipulations and scientific and mystical ideas. In fact, in pursuing my studies of the history of science, I have met, in the examination of the Latin works of the middle ages, certain technical manuals which were related most directly with the metallurgical treatises of the Greco-Egyptian alchemists and goldsmiths. I purpose to

demonstrate here this correlation, which nobody has till now pointed out.

It is known that the receipts of therapeutics and *materia medica* have been preserved in a parallel way by practice, which has never ceased, in the Receptaries and other Latin treatises; these treatises, translated from the Greek during the period of the Roman Empire, and compiled in the first and second centuries, passed from hand to hand, and were copied frequently during the earlier portions of the middle ages. The transmission of the military arts and of fire-producing formulas, particularly, was carried on from the Greeks and Romans through the barbarous ages. In short, the necessity of the applications has always caused the subsistence of a certain experimental tradition of the arts of ancient civilization.

The oldest technical treatises in Latin of the middle ages on subjects in chemistry with which we are acquainted are the Formulas for Dyeing (*Compositiones ad tingendo*), of which we have a manuscript written toward the end of the eighth century, and the Key to Painting (*Mappæ clavicula*), the oldest manuscript of which is of the tenth century. The Formulas for Dyeing is not a methodical work, but a book of receipts and documents collected by a dyer for use in his art and intended to furnish him with working processes and information concerning the origin of his prime materials. It concerns such subjects as the coloring or dyeing of artificial stones for mosaic work; gilding and silvering and polishing them; making of colored glass in green, milky white, various shades of red, purple, yellow—the colors being both deep and superficial, and often brought out by the aid of simple varnishes; coloring of skins in purple, green, yellow, and various reds; dyeing of woods, bones, and horns; notices of minerals, metals, and earths used in goldsmiths' work and painting. Curious ideas are set forth on the function of the sun and of heat, peculiar to certain warm earths in the production of minerals endowed with corresponding virtues; while a cold earth produces minerals of weak quality. This reminds us of the theories of Aristotle on dry exhalation as opposed to moist exhalation in the generation of minerals—theories that made an important figure in the middle ages.[1] The author distinguishes a feminine and light lead mineral as against a masculine and heavy mineral; a distinction like that mentioned by Pliny between male and female antimony, the male and female blue of Theophrastus, and many others. Minerals were continually likened in the chemistry of the middle ages to living beings.

We read likewise in this work of articles developed in certain operations, such as the extraction of mercury, lead, the roasting of sulphur, preparations of white lead with lead and vinegar, of

verdigris with vinegar and copper—already described by Theophrastus and Dioscorides—of cadmies, impure oxides of lead and zinc, of burned copper (*aes ustum*), of litharge, of orpiment, of artificial cinnabar, etc. The writer mentions a few alloys, such as bronze, white copper, and gold-colored copper—a subject often treated of by the Greek alchemists, who passed from it to the idea of transmutation. The name of bronze (*brundisium*) appears for the first time. While its origin has been the subject of controversy among philologists, the accompanying facts given in the text show that bronze was in the beginning an alloy made at Brundisium for the manufacture of the mirrors of which Pliny speaks. The preparation of parchment and of varnish, the fabrication of vegetable colors for the use of painters and illuminators, and their employment on walls, wood, canvas, etc., in encaustic or with isinglass, are the subjects of separate articles.

A group of formulas for gilding follow: gilding of glass, wood, skins, clothing, lead, tin, and iron; and the preparation of golden wires, processes for writing in golden letters (chrysography) on parchment, paper, glass, or marble. Then come silver foil, tin foil, and processes for reducing gold and silver to powder, in which mercury and verdigris were employed—the powder obtained by amalgamation being employed in processes for silvering and gilding. The process has played its part in political economy; for it has been used to assist the passage of gold and silver from one country to another, in spite of the prohibition of the exportation of the precious metals.

The author goes on to say: "We have described everything relative to tinctures and decorations; we have spoken of the substances which are employed in them—stones, minerals, salts, and herbs; we have shown where they are found; whence are got resins, oleoresins, and earths; what are sulphur, black water, salt waters, glue, and all the products of wild and cultivated plants, domestic and marine; beeswax, axunge, all fresh and acid waters; among woods, the pine, fir, juniper, and cypress, . . . acorns and figs. Extracts are made of all these things with a water made of fermented urine and vinegar, mixed with rain water."

These enumerations and descriptions mark the nature of the knowledge sought by the writer, and preserve the trace of ancient treatises on drugs and medicines, similar to those of Dioscorides, but more especially devoted to industry. Unfortunately, we have here hardly else than titles and summary indications, such as would figure in a dyer's scrap-book, placing one after another indications drawn from different authors. Many of the specific names found in the treatise are wanting in the most complete dictionaries. The terms salt, fresh, and acid waters, water formed of fermented urine and vinegar, deserve special notice

because they point to the beginning of chemistry by moist processes. They figured in Pliny and the ancient authors, to the same purposes. The liquids are always natural ones or the results of the mixture of such, before or after spontaneous combustion. There is no mention of the active liquids obtained by distillation, which were called divine or sulphurous waters, and held an important place with the Greco-Egyptian chemists, and became the origin of our acids, alkalies, and other agents; they had not yet entered into industrial use, and are seldom met with previous to the fourteenth century.

The group of receipts transmitted by the formulas for dyeing, passed into a more extended collection called the Key to Painting, of which exist a manuscrip' of the tenth century in the library of Schlestadt and one of the twelfth century, of which an edition was published in 1847 by Mr. Way. The former manuscript is free from all Arabian influence, which has caused the interpolation of five additional articles in the second one. The work contains a treatise on the precious metals comprising now a hundred articles, about half of the original work, the other half having been lost, and a treatise on recipes for dyeing, representing principally those in the Formulas; together with sixteen articles on military ballistics and fireworks, forming a special group; articles on the hydrostatic balance and the densities of the metals; and industrial and magic recipes, added at the end of the book. The treatise on the precious metals is of great interest because of the striking analogies it presents with the Leyden Egyptian papyrus found at Thebes, and with other ancient works. Many of the recipes are literally translated from these ancient works; an identity proving indisputably the continuous preservation of alchemic practices, including transmutation, from Egypt down to the artisans of the Latin West. The theories proper, on the other hand, did not reappear in the West till toward the end of the twelfth century, after they had passed through the Syrians and the Arabs. But the knowledge of the processes themselves was never lost. This fact is demonstrated by the study of the alloys intended to imitate and falsify gold; for coloring (copper) gold-color; for fabricating gold; for making test gold; for rendering gold heavier; and for doubling gold. The recipes are filled with Greek words that betray their origin.

The object for the most part is simply to make base gold, as, for instance, by preparing an alloy of gold and silver, colored with copper. The goldsmith, however, tried to make this pass for pure gold. Then manufactures of complex alloys which were made to pass for pure gold were made easier by the intervention of mercury and sulphurets of arsenic, the use of which goes back to the earliest times of the Roman Empire. Thus Pliny relates

in a few lines an experiment performed by order of Caligula for fabricating gold with sulphuret of arsenic (or orpiment). There was thus a whole special chemistry, now abandoned, which was conspicuous in the practices and pretensions of the alchemists. A patent has been obtained in our own times for an alloy of copper and antimony, containing six hundredths of the latter metal, which presents most of the apparent properties of gold and is worked in the same manner. Alchemic gold belonged to a family of similar alloys. Those who made it fancied besides that some agents played the part of ferments to multiply gold and silver. Before deceiving other people they deluded themselves. Sometimes the artisan was satisfied to use a cement or superficial action, painting the surface of silver in gold or the surface of copper in silver, without modifying the metals in their thickness. This is what goldsmiths still call giving color. They would even do no more than apply to the surface of the metal a gold-colored varnish, prepared with the bile of animals or with certain resins, as is still done. From these colorings the operator, led by a mystic analogy, passed to the idea of transmutation, in the false Democritus and in the Key to Painting. The author of the last work concluded, for example, with the words, "You will thus obtain excellent gold and fit for the test." The author added, further, "Hide this sacred secret, which should be delivered to no one, nor to any prophet." The word prophet betrays the Egyptian origin of the recipe. It refers to the Egyptian priests, who, according to a passage in Clement of Alexandria on the Hermetic books that were borne with great pomp in the processions, were called prophets.

In further proof of the Greco-Egyptain origin of goldsmiths' recipes contained in the Key to Painting is the existence in the Latin collection of ten recipes—some of the elaborate ones—which are phrased in precisely the same terms in the Greek papyrus in Leyden; the former text being translated from the latter, even to the detail of certain technical expressions, which are still perpetuated in the goldsmiths' manuals of the present. This does not mean that the text transcribed in the Key to Painting was originally translated from the very papyrus that we possess, which was not found till the nineteenth century at Thebes, Egypt; but the coincidence of the text proves that there existed books of secret goldsmiths' recipes transmitted from hand to hand of the tradesmen, which continued through the middle ages, and of which the Key is an example. It was firmly believed in the time of Diocletian that the Egyptians had the secret of enriching themselves by making gold and silver; and in consequence of this belief, after a revolt, the emperor ordered all their books burned. Nevertheless, as we have seen, the formulas did not disappear.

The title of one of the recipes in the old table, "How to make unbreakable glass," deserves to be dwelt upon, on account of the legends and traditions that are associated with it, and which have been perpetuated down to our own time. Unbreakable glass appears to have been really discovered under Tiberius, and gave rise to a legend according to which its properties were amplified and it was made malleable. Tiberius, according to Pliny, caused the factory to be destroyed, for fear that the invention would diminish the value of gold and silver." "If it was known," wrote Petronius, "gold would become as cheap as mud." According to Dion Cassius, Tiberius slew the author. Petronius, who is repeated by other authors, says that he was decapitated, and adds that "if vessels of glass were not fragile they would be preferable to vessels of gold and silver."

These stories relate evidently to the same historical fact, reported by contemporaries, but disfigured by legend; the invention was probably suppressed for fear of its economical consequences. It is very curious to find it mentioned in the goldsmiths' recipes of the middle ages, as if the secret tradition had been preserved in the shops. Some of them claimed that glass could be made malleable and ductile and changed into a metal. A process for making glass that will not break has been discovered in our own times, and is announced unequivocally and in definite shape. In truth, malleable glass was not really in question; but even that is not a chimera. Industrial processes for beating and molding glass, based on the plasticity and malleability which it possesses at a temperature near fusion, have been described in late years. An article in the Key to Painting seems to point to a similar process. Real properties, perceived doubtless from antiquity and preserved as shop secrets, gave rise to the legend.

The collection bearing the name of Eraclius or Heraclius is in two parts, of different composition and date. The first part consists of two books in verse, having the character of the writing of the end of the Carlovingian epoch, or of the ninth and tenth centuries. It treats of vegetable colors, of gold leaf, of writing in letters of gold, of gilding, of painting on glass, and of the preparation of precious stones. All the recipes are of ancient origin, a little vague, and without novelty. A book in prose is more compact and precise. It was added later by a continuator, toward the twelfth century, for there is a discussion in it of the coloring of Cordovan leather, and cinnabar, which is red, is called in it azure —a translation of an Arabic word, frequent in the twelfth century, which has given rise to all sorts of misconceptions and confusion with our modern azure blue. It has the stories about malleable glass; and most of the subjects were already treated in the Key to Painting.

The Picture of Different Arts of the monk Theophilus seems to be the work of an author who lived at the end of the eleventh century and beginning of the twelfth. It is more exact and detailed than the work of Eraclius, and is composed of two parts—the first devoted to painting, and the second concerning the making of objects required in worship and the construction of buildings devoted to it. It describes in detail the furnace for melting glass and the manufacture of glass, the making of painted glass and colored earthen vessels, the working of iron, the melting of gold and silver and the working of them, enamel, the fabrication of vessels used in worship—the chalice, monstrance, etc.—organs, bells, cymbals, etc. The facts are curious, for they show that the industry of glass and metals had finally concentrated around the religious edifices. But the chemical technique is the same as that of the other books, though savoring of more modern influences; it brings us directly to the thirteenth and fourteenth centuries, from which period monuments and writings multiply more rapidly down into modern times. The derivation of technical traditions from antiquity becomes less and less manifest as intermediaries multiply and the arts tend to assume an original character.

The facts I have presented deserve our attention as a whole, in view of the course and renascence of scientific traditions. Sciences begin in fact with practice. The first object is to satisfy the necessities of life and the artistic wants that awaken early in civilizable races. But this same practice at once calls out more general ideas, which appeared first among mankind in a mystic form. With the Egyptians and Babylonians the same persons were at once the priests and the men of science. Thus the chemical industries were first exercised around the temples. The Book of the Sanctuary, the Book of Hermes, and the Book of Kemi, all synonymous denominations with the Greco-Egyptian alchemists, represent the earliest manuals of those industries. It was the Greeks, as in all other scientific branches, who gave these treatises a revision freed from the old hieratic forms, and who tried to draw from them a rational theory, capable in its turn, by a similar application, of pushing the practice forward and of serving as a guide to it. But the chemical science of the Greco-Egyptians never rid itself of the errors relative to transmission—which were sustained by the theory of primal matter—or of the religious and magic formulas formerly associated in the East with every industrial operation. Yet when scientific study proper perished with Roman civilization in the West, the wants of life kept up the imperishable practice of the shops with the progress required in the time of the Greeks, and the chemical arts subsisted; while the theories, too subtile or too strong for the minds

of the time, tended to disappear, or rather to return toward the ancient superstitions. In the Key to Painting, as in the Egyptian papyrus and the texts of Zosimus, are mentions of prayers to be recited during the operations; and in this way alchemy remained intimately connected with magic in the middle ages as well as in antiquity.

When civilization began to revive during the Latin middle ages, toward the thirteenth century, in the midst of a new organization, our races took up anew the taste for general ideas, and these, in the sphere of chemistry, were sustained by practices, or rather they obtained their support in the permanent problems raised by them. Thus the alchemistic theories were suddenly revived, with new vigor and development, and their progressive evolution, while improving industry, gradually eliminated the superstitions of former times. Thus was finally constituted our modern chemistry, a rational science, established on purely experimental bases. The science was therefore born in its beginning of industrial practices; it kept course with their development during the reign of ancient civilization; when science went down with civilization, practice survived and furnished science a solid ground on which it was able to achieve a new development when the times and the minds had become favorable. The historical connection of science and practice in the history of civilizations is therefore manifest. There is in it a general law of the development of the human mind.—*Translated for The Popular Science Monthly from the Revue des Deux Mondes.*

SKETCH OF SIR JOSEPH HENRY GILBERT.

ON the 29th of July, 1893, the little village of Harpenden, in Hertfordshire, England, witnessed a rare ceremonial and was stirred by unusual emotions. The presidents of the scientific societies of England were there, with other of the most eminent men of science in the kingdom and foreigners of like standing; while others, their peers, were represented by letters. Mr. Herbert Gardner, M. P. and Minister of Agriculture of the United Kingdom, presided; by his side were the Duke of Devonshire, President of the Royal Agricultural Society; the Duke of Westminster, who, as chairman of the Executive Committee of the Rothamsted Jubilee Fund, might be considered as manager of the business for which the meeting was held; Lord Kelvin, President of the Royal Society; Dr. Michael Foster; Dr. H. E. Armstrong, President of the Chemical Society; Prof. Charles Stewart, President of the Linnæan Society; Sir J. D. Hooker; Sir John

Evans, Treasurer of the Royal Society and Honorary Treasurer of the Rothamsted Jubilee Fund; the Earl of Clarendon, Lord Lieutenant of the County of Herts; Sir John Lubbock, M. P., Trustee of the Lawes Agricultural Fund; Mr. Ernest Clarke, Secretary to the Royal Agricultural Society of England and Honorary Secretary of the Rothamsted Jubilee Fund; representatives of the Société des Agriculteurs de France; and other men whose names are as significant and representative. Letters were read from the Prince of Wales, to whom is given the credit of having originated the celebration; Prince Christian; the Marquis of Salisbury; Prof. Huxley; Sir Gabriel Stokes; M. Tisserand, Director of Agriculture for France; the Association of Experimental Stations in Canada and the United States; M. Pasteur; M. Déhéran, and other foreigners famous in science. These distinguished guests were assembled, and the ceremonies of the day were performed, to do honor to the work of two men—plain farmers, we might correctly call them—who had spent their lives in the study of the best means of improving the yield and quality of agricultural crops—Sir John Bennet Lawes and Mr. Joseph Henry Gilbert.

We have already given, in a sketch of J. B. Lawes, in Volume XXVIII of The Popular Science Monthly, a brief account of the early history of the Rothamsted Agricultural Experiment Station.

It was established by Mr. Lawes on the estate which he entered by inheritance in 1834. He had been engaged for several years in chemical experiments, chiefly with reference to the preparation of drugs. As he wrote to a friend in 1888, he had not thought of any connection between chemistry and agriculture till his attention was attracted by the remark of a gentleman, who farmed near him, that on one farm bones were invaluable for the turnip crop, and on another farm they were useless. A quantity of precipitated gypsum and spent animal charcoal was offered him; he was using much sulphuric acid in his drug experiments; and here he had materials for applying superphosphate and enlarging and extending to the field experiments which he had begun with plants in pots. In 1843 Mr. Joseph Henry Gilbert became associated with Mr. Lawes, and the experiments have been continued since then without interruption under the joint direction of the two. The celebration we have mentioned was held to commemorate the fiftieth anniversary of this connection and of the beginning of the real work of the Rothamsted Station. Both men were entitled to equal honor in remembrance, and both received it in the tributes which were offered.

Mr. GILBERT was born at Hull, August 1, 1817. His father was the late Rev. Joseph Gilbert, and his mother was well known as an author, under the name of Ann Taylor of Ongar. After

going through school he was injured by a gunshot, by which his health was impaired for a time, and he lost the use of one eye. He entered the University of Glasgow, where he gave special attention to chemistry and worked in the laboratory of the late Prof. Thomas Thomson. Next he went to University College, London, where he attended the classes of Prof. Graham and others, and worked in the laboratory of the late Dr. Anthony Todd Thomson. Having spent a short time in the laboratory of Prof. Liebig, at Giessen, and received the degree of Ph. D., he returned to University College, London, and acted as class and laboratory assistant to Prof. Thomson in the winter and summer sessions of 1840–'41, attending other courses in the college at the same time. After this he devoted some time to the chemistry of calico-printing, dyeing, etc., in the neighborhood of Manchester. From 1843, when he became associated with Mr. Lawes at Rothamsted as director of the laboratory, his career has been recorded in the history of that institution; and it is difficult to separate the work of the two, who have co-operated harmoniously and efficiently. The results of their investigations have been published in a series of papers, now numbering more than a hundred, in various journals, among which may be mentioned: The Proceedings and Transactions of the Royal Society, the Journal of the Royal Agricultural Society of England, the Journal of the Chemical Society, the Reports of the British Association for the Advancement of Science, the Journal of the Statistical Society, the Journal of the Society of Arts, etc.; also in official reports and elsewhere.

Dr. Gilbert was elected a member of the Chemical Society in 1841, the year of its formation, and he contributed to the first volume of its memoirs a translation of a paper on the Atomic Weight of Carbon, by Prof. Redtenbacher and Prof. Liebig. He was president of the society in 1882–'83. He was elected a Fellow of the Royal Society in 1860, and in 1867 the council of the society awarded to him, in conjunction with Mr. Lawes, one of the royal medals. He is also a Fellow of the Linnæan Society and of the Royal Meteorological Society. He was President of the Chemical Section of the British Association in 1880. He traveled considerably in the United States and Canada in 1882 and 1884, studying the conditions of the agriculture of these countries. He was appointed Sibthorpian Professor of Rural Economy in the University of Oxford in 1884, and was reappointed for a second period of three years in 1887. He has honorary degrees from the Universities of Oxford, Glasgow, and Edinburgh. He is a life governor of University College, London, an honorary member of the Royal Agricultural Society of England, of the Chemico-Agricultural Society of Ulster, of the Academy of Agriculture and Forestry of

Petrovskoie, and of the Royal Agricultural Society of Hanover; foreign member of the Royal Agricultural Academy of Sweden; and corresponding member of the Institute of France (Academy of Sciences), of the Society of Agriculturists of France, of the Society for the Encouragement of National Industry, Paris, and of the Institut Agronomique of Gorigovtsk. He is also Chevalier du Mérite Agricole, France, and, in conjunction with Sir J. B. Lawes, gold-medalist of merit for agriculture, Germany.

At the celebration of July 29th, separate testimonials, read by the Duke of Westminster, were addressed to the colleagues by the Prince of Wales. To Mr. Gilbert the prince said, offering his congratulations on the completion of fifty years of the joint continuous labors of the two in the cause of agricultural science: "The nature and importance of these labors are so well known that it is needless to dilate upon them; but if the institution of the various investigations has been due to Sir John Lawes, their ultimate success has been, in a great measure, secured by your scientific skill and unremitting industry. Moreover, by your lectures and writings you have been a leading exponent in this and other countries of the theoretical and practical aspects of the researches that have been undertaken at Rothamsted. A collaboration such as yours with Sir John Lawes, already extending over a period of upward of fifty years, is unexampled in the annals of science. I venture to hope for an extended prolongation of these joint labors, and trust that the names of Lawes and Gilbert, which for so many years have been almost inseparable, may survive in happy conjunction for centuries to come."

The address from members of the Royal Agricultural Society to Mr. Gilbert declared that "in the organizing and systematic arrangement and record of the researches conducted at Rothamsted you have had a leading share; and you have there set before us a model of what all work and experimental inquiry should be. Your investigations into the applications of chemistry to the cultivation of crops and the feeding of live stock have been of the highest possible importance to the practical agriculturist, and the sincere thanks of the agricultural community at large are due and are hereby tendered to you for the scientific skill and indefatigable industry which you have brought to bear upon the conduct of the Rothamsted researches. The Royal Agricultural Society of England is proud of ranking you among its honorary members, and it desires to take this opportunity of expressing its indebtedness to you for your ever-ready counsel and assistance, as well as for the many admirable and exhaustive papers which, in conjunction with Sir John Lawes, you have contributed to the society's journal."

The Royal Society's address disclaimed any attempt in any

way to distinguish Mr. Gilbert's share from that of his colleague "in the remarkable work which has, with so much skill and patience, been so long carried on, and, indeed, they know that you would not wish that they should; but they desire to say to you, as they have said to him, that the society is justly proud of your labors. They are glad to bear in mind that the society has been the channel through which most of your more important results have been made known, that for more than thirty years you have been enrolled among the number of its fellows, and they believe they can say that the society has always given you such aid and support as lay in its power. They reflect with satisfaction that the researches at Rothamsted have contributed in a remarkable manner to the advancement of that branch of natural knowledge with which they deal, and your connection with the society gives the president and council, they venture to think, the right to feel something like a paternal pride in the success of an undertaking of which the jubilee marks a stage." The joint address to the two of the Chemical Society recognized the long adherence to the same plan of experiment as evidence of the skill displayed in its inception and as giving to the work its peculiar value, and continued: "While affording guidance to the agriculturist, your researches have elicited information which will ever serve as the foundation of a truly scientific knowledge of the correlation of plant growth and manurial constituents of the soil, and will be of the utmost value in all discussions of the chemistry of plant life. Your researches on the feeding of animals, in like manner, are not only of practical importance, but also shed much light on the processes of animal life." But of even far greater value was the example which their single-minded devotion to the cause of scientific truth and research had afforded to the world. A congratulatory address was received from the Société Nationale d'Agriculture de France.

Sir John Lawes, being called to speak, said that when two persons were joined in marriage they could not part, because they were bound by solemn ties; but the case with respect to himself and Dr. Gilbert was different. Dr. Gilbert could have left him and he could have left Dr. Gilbert at any time during their association. Why had they not done so? Because they had an immense love of the work they were engaged in. Personally, he had delighted in it from the beginning, and had given as much time to it as he could consistently with other duties; but Dr. Gilbert had made it the work of his life. He had been at work not only when he was at home, but had spent what were called his holidays in visiting other countries and places, in putting himself into communication with other bodies, so that he might make his own work more valuable to those at home.

In connection with these remarks it is proper to recall what Mr. Lawes said in 1855, thirty-nine years ago, in his speech at the inauguration of the new laboratory building, erected by public subscription by British agriculturists: "I should be most ungrateful were I to omit to state how greatly I am indebted to those gentlemen whose lives are devoted to the conduct and management of my experiments. To Dr. Gilbert, more especially, I consider a debt of gratitude due from myself and from every agriculturist in Great Britain. It is not every gentleman of his attainments who would subject himself to the caprice of an individual, or risk his reputation by following a science which has hardly a recognized existence. For twelve years our acquaintance has existed, and I hope twelve more years will find it existing." Those "twelve more years" have now increased to thirty-eight "more years," and not the acquaintance only—the close association, too—still exists.

Mr. Gilbert spoke, expressing his gratification at the tributes which had been offered to him, and closed by saying that, however many years were spared to them—and they must necessarily be very few—he hoped they might be able to do something to extend the general knowledge which was the best legacy they could leave to those who would succeed them.

A portrait of Sir John Lawes, by Prof. Hubert Herkomer, representing him as the farmer of Rothamsted, was presented to him, and a silver salver, on which the addresses were deposited, to Dr. Gilbert. A granite bowlder, "turning the scales at eight tons," was set up in front of the laboratory, bearing the inscription, "To commemorate the completion of fifty years of continuous experiments (the first of their kind in agriculture) conducted at Rothamsted by Sir John Bennet Lawes and Joseph Henry Gilbert, A. D. MCCCXCIII." As an additional memorial, forty-four complete sets of the Reports of the Rothamsted Station were presented, at the expense of the nation, to leading public institutions. A few days after the celebration Dr. Gilbert was knighted, "in recognition of his valuable researches for the promotion of agriculture."

A BILL is before the British Parliament to prohibit the raising of unsightly erections—having particular reference to advertising structures—to the harm of the rural scenery of Great Britain and Ireland. It applies to fences, gates, posts, hoardings, etc., and to the posting of any printed or written matter, or any picture, so as to be in view from any highway, railway, etc.; but not to such legitimate advertising as is intended to show that the property is to be let or is for sale, or to publish a business that is there carried on. We have a similar law in New York for the protection of natural scenery that might be applied to the appurtenances of property; but who sees to the enforcement of the law we have?

EDITOR'S TABLE.

SCIENCE, ORTHODOXY, AND RELIGION.

JUDGING by a kind of "symposium" we saw lately in a San Francisco paper, the clergy of that city, or at least some of them, seem to think it their duty to keep a watchful eye on the utterances of the professors of science in the neighboring universities, in order that they may raise a voice of warning should anything be said that threatens to conflict with their ideas of theological orthodoxy. As usually happens in such cases, the men who have fallen under the censure of these guardians of the truth are two of the brightest ornaments of the Western scientific world—Prof. Joseph Le Conte, of the University of California, and President David Starr Jordan, of Stanford University. These eminent scientists had not succeeded in "hitting it off" to the entire satisfaction of their clerical critics, and were consequently attacked by the latter with no little acrimony. To offset this manifestation of narrow-mindedness, however, the Episcopalian Church Club of San Francisco, as we learn, gave a dinner to the incriminated professors, at which liberal, kindly, and rational sentiments were the order of the day. It is to this celebration, if we may so call it, that the discussion which we referred to at the outset relates. Prof. Le Conte, who contributes the first paper, predicts that, when the religious world has succeeded in adjusting itself to the doctrine of evolution, as it has already done to various geological and astronomical theories which it once considered very alarming and heretical, religion will only be the stronger because more rational. Prof. David Starr Jordan makes so bold as to say that "science can not demand anything less than absolute freedom of development; it must be free alike from the need of premature decisions and of premature reconciliations." He says, moreover, that whatever be the origin of a doctrine or opinion, science claims the right to set it aside if it is found to be scientifically false or unsound. He declines to accept the dictum that there are three kinds of evolution, theistic, agnostic, and atheistic, and that these must be carefully distinguished. He says there is but one kind of evolution, and that the epithets in question have no application to it, but only to individuals. What he means, evidently, is that the only kind of evolution a man of science as such can believe in is that which reveals itself to him as the result of his investigations. Mr. W. T. Stead, editor of the Review of Reviews, says (writing from Chicago, where he was at the time) that "it will take a good many banquets to evolutionists before the Christian Church can adequately acknowledge the debts which it owes to the man (Darwin) and the school which revivified the popular conception of the living God."

Thus good comes out of evil. The ecclesiastical mind would fain still impose fetters upon scientific thought, but whenever it makes any open attempt to do so, it is sure in these days to meet with repulse. If our religious teachers would but believe it, there is an ample field open to them for instructing and benefiting mankind without making any attempts to restrict scientific investigation or the enunciation of scientific doctrines. It is theirs to interpret to their fellow-men—in so far as they may be sufficient for the task—their deepest relations to the universe in which they live. The hygienist may tell us how to maintain our physical health, the sociologist how to govern ourselves as members of society, the publicist or political

economist how we may advance our own material interests or contribute to those of the community. But there is room for a teaching which shall in a manner correlate all these, which shall reveal the sacredness of every duty and the profound significance of life. This is the teaching which especially deserves the name of religious, inasmuch as it awakens in the mind of the individual a consciousness of his relation to the universe as a whole, and an accompanying sense of universal law. Who, it may be asked, is sufficient for these things? Not every one assuredly who enters on the clerical profession. It is a vastly easier thing to denounce science as heterodox than to minister in any effective manner to the higher life of one's fellows. The latter, however, is the true function of the religious teacher, not the former; and it is a function the need for which was never greater than it is to-day. Science is advancing with giant strides, but discontent is on the increase. Why? Because the essential conditions of happiness are ignored; because rich and poor, however diverse their points of view in other respects, join in affirming that life consists in material abundance, that character is of little account, that money can do everything. In such a condition of things it is really surprising that religious teachers should find time to attack men of science for any views whatever which they may promulgate, the need being so pressing for a manifestation of those moral truths which no scientist would think of opposing, and which in point of fact no scientific doctrine can be said to touch. The fields are white to the harvest, but the really competent reapers are few. They would be more numerous perhaps if the needs of the time were better understood, and if men were not required to undergo an apprenticeship to outworn systems of thought before betaking themselves to the work of the ministry. We ask our religious friends to think of this. Science can not be arrested in its investigations, but these need not and do not stand in the least in the way of true religious work. Let the scientists, therefore, occupy their own field without molestation, and let the clergy—those who are fit for their high office—occupy their own field and labor to promote higher views of the worth and destiny of human life than those ultra-material ones which are so widespread to day, and which are nowhere more conspicuous than in the churches. Then we may have peace with progress.

A DANGEROUS CLASS.

In an article on The Unemployed, which appered in last month's Table, we ventured the opinion that one reason why the number of these was so great was that thousands of persons in the present day were receiving an education which they were not able afterward to put to any satisfactory use; and from an article by Mr. Goldwin Smith, which fell under our eye just as our own was finished, we were able to quote a passage strongly confirmatory of the position we had taken. Years ago Prince Bismarck had said the same thing in regard to Germany, and we remember how sharply a certain college president in this country resented the idea that college classes could by any possibility be too large, or engineers, architects, chemists, lawyers, doctors, etc., qualified or semi-qualified, be in too great proportion to the rest of the community. Of course, the financial prosperity of a college depends in a measure on the number of students it can attract, and we can understand why college authorities might not like the idea to get abroad that to send a boy to college is not always the wisest thing to do with him. Still, the truth that college education and semi-education can be overdone is one that, in our humble opinion, is destined to force itself, despite all that col-

lege presidents can say to the contrary, on public attention.

As regards Germany the opinion which, as we have said, Prince Bismarck expressed years ago is strongly confirmed by Mr. William H. Dawson's recent work on Germany. We take the following summary of his observations on this question from the London Saturday Review:

"He draws a very gloomy picture of the result of too many universities and too much higher education. We should like to think he exaggerated here, but we are forced to admit he does not. Twenty-two seats of learning are yearly 'turning out studied men in thousands,' and the unfortunate 'studied men' are lucky if, at the age of thirty-five, they are earning the wages of English bank clerks. The paternal state finds money for universities and looks to the qualifications for the professions and the civil service; but that paternal state can not provide its carefully examined would-be lawyers and doctors and civil servants and teachers with briefs and patients and posts and pupils; and, as a consequence, the educated unemployed increase mightily in numbers year by year. Still more formidable are the 'breakages'—the horde of superficially book-learned young fellows of the middle and lower middle ranks whom stupidly ambitious fathers have sent to universities (the state aiding) to fail in examinations when they ought to be selling groceries or hoeing potatoes. These undoubtedly form a truly 'dangerous class'; unfit for real intellectual effort, they have just sufficient smattering of letters, philosophy, economics, and science to make them the readiest tools of the agitator and the most permanent and effective nuisances to society, against which they have the very real grievance that they are unable to serve it in any useful way."

We have the case here very succinctly stated. These are the men who say that "the world owes them a living," the truth being that they have contracted a debt both for previous living and for education which they have little prospect of ever being able to wipe out. The sooner we recognize the fact that our modern systems of education are largely experimental, and that much of the way we have gone may have to be retraced, the better it will be for the permanent peace of society. At present we are using too much yeast of a not very wholesome kind, and the result is an excessive and dangerous amount of social fermentation.

LITERARY NOTICES.

THE STORY OF THE SUN. By Sir ROBERT S. BALL, F. R. S. Eleven Plates and Eighty-two Illustrations. 8vo. New York: D. Appleton & Co. Pp. 376. Price, $6.

THIS great story, draped in its simple yet eloquent diction, will perchance recall to the reader's mind some bygone evening when, by the shore of a sheltered and tranquil lake, he may have beheld reflected in its depths the crumbling glories of a nation's ancient structure, intermingling with the pinnacles of the modern edifice, devoted to the promotion of science in its latest reaches of infinite research. In such a scene, what food may not one find for reflection in a mental as well as the physical sense! The simile drawn may stand as reverting to certain antique theories of the sun, when contrasted with our nowaday ascertainable data.

Indeed, if this latest work of Sir Robert S. Ball were presented to the student stripped of all but the illustrations, it would, we feel assured, be pronounced a uniformly artistic and harmonious story without words. In the author's preparation of the work he gratefully acknowledges the assistance rendered him by such marked names in astronomical science as Prof. Pickering, of Harvard College Observatory; the famous French *savant* M. Flammarion; Prof. Holden, of Lick Observatory; Prof. Janssen, and many others. Even the reading of proofs was consigned to the charge of four unquestionable authorities. In all these aids, the essential purport of the volume, including such pronounced care, purity of style, logic-

al analysis, and the very latest research, must appeal to the reader through every line. In fact, wherever the spirit of inquiry inducing mathematical precision is found to supplant the imports of theory submitted on authority, this work will doubtless find a place; while, as registering unerringly the progressive steps taken to elucidate ascertainable knowledge regarding our great luminary, the scientific explorer can tread no safer ground than that prepared by the author.

In the opening chapters the principal features attaching to our solar system are submitted in detail, and it is shown that the sun in numerous senses becomes a center, apart from the geometrical position he occupies amid our own planetary system. For the fundamental elements of calculation needed to determine the true character of the sun we are indebted to the varying positions of the planets and the measurements they afford. Remotest antiquity, and the doctrines it taught concerning the solar system, are then treated at length, and contrasted with the advances made down to our own time. A problem of the utmost importance in all astronomical deductions—the actual distance of the sun—is treated of amply in the second chapter, where its leading characteristic is pointed out as involving the indirect method of computation. This distance becomes an abiding element in any conclusions to be drawn regarding the magnitude and nature of the solar spots, besides furnishing data for all prominences projected during a solar explosion, or as limiting the measure of the solar corona when expressed in miles.

The famous transits of Venus—which, by the way, afforded formerly the most trustworthy method of obtaining scales of the solar system—are commented upon at length in Chapter III, though, as the author points out, they now possess for astronomers but a historical interest. In connecting the sun's distance with the laws governing the velocity of light, a beautiful series of reasonings ensue, until we are introduced to the methods of measurement determining the sun's mass. Eclipses, and the story of the sun's spots, are magnificently illustrated and told with an ease and beauty only betimes found associated with a rare romance. Our seasons, past and present, fall next into line for their due share of philosophical comment and mathematical calculation; while "the sun as a star" assumes the unexpected garb of a diminishing speck of light in fathomless space, to be finally lost to the finite eye. In the closing chapter, the movements of the solar system, contemplated as a unit in space, are accounted by the author "one of the most daring exploits ever performed by astronomers," and brings this transcendent Story of the Sun to a close.

Factors that here and there throughout the volume break the intensity of interest excited in the reader are only momentarily dwelt upon as associated with special questions, which again, in their turn, rivet the attention. In a word, the scope of the writer's inquiry, like the boundlessness of his subject, becomes in the perusal a flood of light. In this we are lost by the hour, and our waking moments only seem to recall those breathless flights in childhood's wonderland, but, with this one and wide distinction, that our fancies only then revelled, where now, we feast on fact.

SPEECHES AND ADDRESSES OF WILLIAM McKINLEY. FROM HIS ELECTION TO CONGRESS TO THE PRESENT TIME. New York: D. Appleton & Co. Pp. 664. With Portraits. Price, $2.

GOVERNOR MCKINLEY is a politician of whom his most zealous opponents speak with general unqualified respect. They recognize his earnestness and sincerity, even though they may believe his views to be mistaken and mischievous. The present volume contains sixty-five of his speeches and addresses, selected from several hundred delivered in all parts of the country, by Mr. Joseph P. Smith, Librarian of the Ohio State Library, and revised by Mr. McKinley. Attention is invited by the editor to the care and ability with which Governor McKinley has discussed the tariff. All his more important speeches are collected and presented here, and probably embrace the most and strongest that can be said in favor of the doctrine of high protection. Besides, there are speeches on Gerrymandering, the Suffrage, and the Elections Bill, Labor, Pensions, the Public Schools, Civil-service Re-

form, the Currency, the Hawaiian Treaty, Memorial Addresses on Garfield, Logan, Grant, and Hayes; and several occasional addresses.

A STANDARD DICTIONARY OF THE ENGLISH LANGUAGE. Volume I, A–L. Edited by ISAAC K. FUNK, D. D., Editor in Chief; FRANCIS A. MARCH, LL. D., L. H. D., Consulting Editor; and DANIEL S. GREGORY, D. D., Managing Editor. New York: Funk & Wagnalls Company. Pp. 1060. Price (of two-volume edition, complete), russia, $15; morocco, $20.

THERE are more new departures in this work than in any other English dictionary that has appeared in the past half-century. In the arrangement of the matter under each word the greatest good of the greatest number has been deferred to rather than any historical or logical considerations. The order is, the respelling for pronunciation, the most common present meaning, less common uses, the original meaning if now obsolete or rare, and last the derivation. By this procedure the derivation and antiquated definitions, which are not wanted one time in six that even a comprehensive dictionary is consulted, are not placed where one must wade through them in order to get from the word to its present meaning. In the respelling for pronunciation the scientific alphabet devised by the American Philological Association is used, being supplemented by a few diacritic marks. The main features of this alphabet are those now adopted in all scientific notation of speech—namely, vowel sounds are represented as in Italian (or German) and consonants as in English. The dictionary, while recording all reputable usages in spelling, takes a positive stand in favor of simplification. The systematic spellings of chemical terms adopted by the American Association for the Advancement of Science are given preference over the old forms, being used in definitions. The moderately reformed spellings jointly approved by the Philological Society of England and the American Philological Association are inserted in the vocabulary, but the words that appear thus are defined under the common forms. The illustrations in the text are numerous, and besides these there are in Volume I full-page groups of cuts illustrating *architecture*, *coins* (ancient), *fowls*, and *horses*, also colored plates of *birds*, *decorations* (double page), *flags* (double page), and *gems*. The movements of many animals are illustrated from Eadweard Muybridge's photographs. Many names of classes have under them lists or tables of the varieties belonging to these classes. Thus under apple is a list of nearly three hundred varieties, the size, form, color, quality, use, season, and range of each being indicated briefly. Similar though less extensive lists are to be found under American (race), balsam, blue, calendar, constellation, dog, element, green, and many other words. The defining for this work has been largely done by specialists, and as a rule only a small class of words, with which he is especially familiar, has been submitted to each of these collaborators. Quotations used to illustrate definitions are exactly located. Lists of synonyms and antonyms are given for a large number of words. The vocabulary is very large; it will contain over fifty thousand more words than the six-volume Century Dictionary. The compounding of words has been treated systematically, special attention has been given to handicraft terms, and there are yet other notable features which we lack space to even enumerate. The Standard Dictionary is sure to make many friends and they will be firm friends.

OUTLINES OF PEDAGOGICS. By Prof. W. REIN. Translated by C. C. and IDA J. VAN LIEW. Syracuse, N. Y.: C. W. Bardeen. Pp. 199. $1.25.

THE aim of this work is to furnish a brief introduction to the Herbartian pedagogics, on whose principles it is based. It presents the author's views as to the modern adaptation of those principles, a very important point; for while every thorough student of pedagogics must ultimately refer to the prime foundation—the works of Herbart himself—he can not afford to neglect the results that more than fifty years of development since Herbart's death have produced. The second edition of the author's work contained some essential additions and changes, on account of which certain parts of the first edition were removed to make room for the new. The omitted parts are restored in the translation, and all that both editions contained has been combined. The subject of pedagogics is divided by the au-

thor into Systematic and Historical Pedagogics; and Systematic into Practical and Theoretical Pedagogics. The systematic department is surveyed in the present volume.

ADDRESSES HISTORICAL AND PATRIOTIC, CENTENNIAL AND QUADRENNIAL, delivered in the Several States of the Union, July 4, 1876–1883; including Addresses commemorative of the Four Hundredth Anniversary of the Discovery of America, 1892–1893. Edited by FREDERICK SAUNDERS. New York: E. B. Treat. Pp. 1048.

IN this portly volume are grouped the choicest of the great number of the eloquent and patriotic orations delivered in the several States of the Union during the series of centennial and multi-centennial anniversaries through which we have passed since 1876. They include many of various qualities of beauty and eloquence; many well-matured epitomes of the essential qualities of patriotic citizenship, many lessons pointing out what in our history is to be admired, and some things, perhaps, to be avoided. The facts and sentiments embodied in them cover the whole period of American history from the landing of Columbus down to the year 1893. They have been submitted to the critical supervision of their several authors. The publishers suggest that the reading of the book will tend to inspire a higher patriotism, and imbue the mind with true American principles. They ought to; but the result will depend upon the extent to which readers keep their minds clear from partisan blindness, which so often leads the best of us to the contradiction of what is right and best for the country.

THE POTTERY AND PORCELAIN OF THE UNITED STATES. An Historical Review of American Ceramic Art from the Earliest Times to the Present Day. By EDWIN ATLEE BARBER. With Two Hundred and Thirty-three Illustrations. New York: G. P. Putnam's Sons. Pp. 446. Price, $5.

THE author sets out with a contradiction of the impression, not sufficiently controverted even by our own writers, that the United States has no ceramic history. "On the contrary," he says, "it can be shown that the fictile art is almost as ancient in this country as in Great Britain, and has been developed in almost parallel, though necessarily narrower, lines." The work is based almost entirely upon thorough personal investigations, with patient and systematic research, study of the products of the potteries of the United States, and consultation with intelligent potters in the leading establishments. Care has been taken to omit "some of the time-honored fallacies which have been perpetrated by compilers," and to avoid the use of statements that could not be substantiated. Without attempting to give the history of every pottery that is or has been established in this country, the main purpose of the work is to furnish an account of such of the earlier potteries as for any reason possess some historical interest, and of those manufactories which, in later days, have produced works of originality or artistic merit. Beginning with a description of the processes of manufacture and a list and definition of American wares and bodies, the work treats, further, of aboriginal pottery, early brick and tile making, early potting in America (seventeenth century), potteries of the eighteenth century, operations during the first quarter of the present century, the American china manufactory, the pottery industry from 1825 to 1858, pottery work at East Liverpool and Cincinnati, Ohio, and Trenton, N. J., potteries established between 1859 and 1876; development of the ceramic art since the centennial, tobacco pipes, ornamental tiles, architectural terra cotta, American marks and monograms, and tiles for decorative effect. The author expresses himself highly gratified to be able to call the attention of lovers of art to the remarkable progress which has been made in ceramic manufacture among us within the past fifteen years; and adds that if his efforts shall result, in any measure, in the breaking down of that "unreasonable prejudice which has heretofore existed against all American productions," he shall feel that he has been abundantly rewarded. In his chapter of Concluding Remarks he observes that "thus far our potters have been, in a great measure, imitative rather than inventive, and the result is that we have largely reproduced, though in a most creditable manner, patterns and designs, bodies, glazes, and decorations of foreign factories. With some few exceptions, our commercial manufacturers have been content to copy and imitate the products of foreign establishments, and have, in

consequence, unconsciously assisted in perpetuating certain offenses against good taste." The feeling that prefers articles and designs at first hands can hardly be called an unreasonable prejudice. Whatever it is, originality, with equality of merit, will go far to counteract it. It will be worth trying as a substitute for a McKinley tariff. Mr. Barber believes that "America, within the next few decades, is destined to lead the world in her ceramic manufactures." The work is sumptuously presented by the publishers in the best style of bookmaking.

GEOLOGICAL SURVEY OF NEW JERSEY. ANNUAL REPORT OF THE STATE GEOLOGIST FOR THE YEAR 1892. By JOHN C. SMOCK, State Geologist. Trenton: The John L. Murphy Publishing Company. Pp. 367, with Maps.

IN this report are incorporated, as leading heads or parts thereof, the reports of progress made in the various lines of investigation of the several departments of the works of the survey, as follows: Surface Geology; Cretaceous and Tertiary Formations (preliminary report); Water-supply and Water-power; Artesian Wells in Southern New Jersey; and the Sea Dikes of the Netherlands and the Reclamation of Lowlands and Tidemarsh Lands. These reports are to some extent separate and independent of one another, although all have for their object the elucidation of the facts of the geological structure and physical geology of the State, and as an ultimate end the information of the people in order to the highest development of the natural resources of the State. The administrative report, introductory to the reports of the several divisions, besides remarks on the topics already mentioned, has discussions of drainage; natural parks and forest reservations; the work of the United States Geological Survey in New Jersey; and the geological survey exhibit for the Columbian Exposition.

The maps represent the whole State, with reference to its water-supply sheds, and the special geology of parts of Monmouth and Middlesex Counties. The treatment of all the subjects is full, satisfactory, and adapted to practical ends; and the report is, as a whole, one of the most interesting the survey has issued.

PRIMER OF PHILOSOPHY. By Dr. PAUL CARUS. Chicago: The Open-Court Publishing Company. Pp. 232. Price, $1.

THE author seeks to present his subject in the plainest and simplest manner he can. His point of view is not susceptible, he says, of being classified among any of the various schools of recent current thought, but represents rather a critical reconciliation of rival philosophers of the type of Kantian apriorism and John Stuart Mill's empiricism. The names of positivism and monism are taken as expressing the philosophical principles which dominate modern thought. Either is complementary to the other. Positivism represents the principle that all knowledge —scientific, philosophical, and religious—is a description of facts; monism is a unitary conception of the world, presenting it as an inseparable and indivisible entirety. It stands upon the principle that all the different truths are but so many different aspects of one and the same truth. Monistic positivism or positive monism "is, and always has been, the principle of all sound science. The positive and monistic maxims of philosophy were perhaps not sufficiently appreciated in former ages, but they are growing to be clearly understood now, and will in time lead to the abandonment of all transcendental, metaphysical, supernatural, and agnostic speculations. Positive monism will change philosophy into a systematization of positive knowledge."

NUMBER WORK IN NATURE STUDY. By WILBUR S. JACKMAN. Chicago: W. S. Jackman. Pp. 198. Price, 60 cents.

IN secondary schools the study of mathematics demands a large share of the pupil's attention, and little effort has been made thus far to rescue the hours passed in solving arithmetical puzzles or algebraic enigmas. Even in grammar schools it is excellence in arithmetic rather than in the construction of language which forms the standard of scholarship. The author of this manual believes that much of the time spent in mastering arithmetical processes could be also utilized in Nature study. If the pupil obtains material, makes his own observations and comparisons, the mechanism of the subject will be incidental, and instead of meaningless results or unintelligible values

he will gain thereby an idea of some general law. To remedy the frequent inexactness of beginners, it is advised that continual use should be made of balances, weights, rulers, and protractors, and definite quantities always required. The mathematics involved are the four fundamental rules of arithmetic, fractions, ratio, and percentage, and the problems for study are sufficiently varied, being taken from seven departments of science.

The method is good, but several of the subjects appear beyond the grasp of a pupil in percentage. While interest may be aroused in the colors of insects, the constituents of fruits, or the process of evaporation, it is hardly possible that the ratio of the area lying south of the mean annual isotherm of 50° Fahr. to that lying south of the mean annual isotherm of 40° Fahr., or calculations of rainfall and drainage, should be more comprehensible or attractive to the average boy than questions in taxation and insurance.

PLATO AND PLATONISM. By WALTER PATER. London and New York: Macmillan & Co. Pp. 256. Price, $1.75.

HOWEVER materialistic the mood of the reader may be, these lectures are apt to take him unawares and hold him for a time completely under their spell. He wanders amid the groves of the Academy and listens to Socratic dialogue until he becomes somewhat hypnotized and is prepared to meet the Just and the Beautiful face to face. Not that Mr. Pater inculcates the possibility of any such actual vision. He pronounces the theory of the many and the one difficult doctrine and acknowledges that, with all allowance for poetical expression, the universals to which Plato would introduce us are very much like living beings.

In order to form a just or historic estimate of Platonism, the conditions of its genesis and growth must be examined. Mr. Pater projects for us in vivid outline the Greek intellectual life preceding Socrates. The philosophy of Plato was a protest against the doctrine of Heraclitus. His dogma of universal change, *πάντα ῥεῖ*, is not unlike the modern idea of development and evolution, but to Plato it was in the highest degree repugnant. Recognizing the tendency to vary, he considered it an evil to be corrected, and sought in the nature of man, in culture, in society, for an unalterable *κόσμος*. In the Republic he shows how this order may be established in a community.

Personally, Plato is depicted not as a rigid philosopher wrapped in speculations, but as a keenly impressionable nature with every sense sharpened to the external world. This gives "an impassioned glow to his conceptions," and endows his writing with the fineness of Thackeray.

According to modern views, two radically divergent tendencies are discoverable in Platonism. First, the theory of ideas, that the highest knowledge is intuitive and absolute. Secondly, the dialectic method, the endless question and answer, the weighing of every minute grain of evidence. Mr. Pater considers that we owe not only this method, "a habit of tentative thinking and suspended judgment," to Plato, but that it is straight from his lips that the language came in which the mind has ever since been discoursing with itself.

In conclusion, if we doubt Plato's immutable ideas, we may still seek for the ideals he pictures. If we reject his communistic theories, we can accept his classification of the orders of men, the intellectual, the executive and the productive. We may even strive to realize his dictum that those who come to office should not be lovers of it! As for his contention with the Sophists, that is a question of to-day. Which is essential, matter or form? Should the artist and writer know and feel the truth himself, or only know what others think about it? If we believe the former, we may go to the Phædrus for inspiration.

GOVERNMENTS AND POLITICIANS, ANCIENT AND MODERN. By CHARLES MARCOTTE. Chicago: Charles Marcotte, 175 Monroe Street. Pp. 478. Price, $2.

THE merits of this work are anything but inconsiderable when viewed from the standpoint of a measurable reforming medium. More. The author's sincerity and thoroughness of purpose manifestly inheres between the lines on every page. We leave it, however, to the judgment of others to say whether the "Constitution" of this country —as alleged—is responsible for the existence of "professional" and "unscrupulous"

politicians as well as the faulty results of our "primary elections." An antagonist worthy of the author's steel might be the Hon. W. E. Gladstone, who declares the "Constitution" in question to be the greatest "fiat" that ever issued from the hands of men. We ourselves have somehow the impression that unscrupulous politicians and packed primaries exist in spite of the Constitution. Nevertheless, the volume before us tends to modify the weight that Americans customarily attach to their non-anyletical method of dealing with national shortcomings and political abuses. Further, the author places us *en rapport* with the monarchical governments of Europe, both ancient and modern, and strenuously argues in favor of similar policies—or at least one such institution—being adopted in the United States. Notwithstanding the trenchant analysis applied, as long ago as and by Lord Bacon, to the faultiness—under specified conditions—of the syllogistic argument, and its invalidity as demonstrated by the late John Stuart Mill; still, Mr. Marcotte very quietly settles the "divine right of monarchy" as follows: "The form of government which best administers justice is of divine right; monarchy is that which best administers justice; therefore, monarchy is of divine right." Evidently our author cares very little or nothing for previous questions.

But the foregoing sample is the very worst feature of a work the contents of which introduce us to such excellent matter as the story of Democracy, the Greek Republics, Media and Persia, the Athenian Commonwealth, the Roman Empire, the Great American Republic, the Origin of the American People, etc. In a second edition of this work the author's genuine good nature will doubtless incline him to deprecate pessimism and anticipate an epoch on this continent when impartiality will have become a necessity and human justice as natural as the law of gravitation.

SECULARISM: ITS PROGRESS AND MORALS. By JOHN M. BONHAM. New York: G. P. Putnam's Sons. Pp. 396. Price, $1.75.

A WORK that forces reflection of an ethical nature will inevitably fill an exalted niche within the radius of scientific activity. Such a volume lies before us and invites the reader's thoughtful consideration for many good reasons. The philosophy underlying the inferences deduced in Secularism will—as far as one can judge—have a twofold effect. Such as may deem it a duty to oppose the author will indubitably have to reconsider their own position, and those who agree with him, will doubtless discover new data wherewith to augment their polemical outfit.

The scope of the question taken up by Mr. Bonham is far from limited by even the copiousness of his book, though the comprehensiveness of the author's design is apparent throughout. The main initial purport of the argument, as a whole, is to examine minutely the relative force of influences bearing upon beliefs theological, in the first place through industrial results, and in the second by such surroundings as are traceable to the intellectual field of view. The next point of import rendered lucid by the author's method of reasoning is the fact that the masses, with but few exceptions, are disinclined to philosophical abstractions, and that those influences which go farthest to build up their ethical natures are discoverable in their occupations and the deductions supplied from inductions gathered through the physical phenomena affecting their daily lives. This would be putting the matter with unwarrantable brevity were we unable or disinclined to further note the exhaustiveness of this engaging book. Besides the superiority of relative truth over the presumptions of supermental dicta being succinctly treated, the history of the decline of theologic anathema against ascertained knowledge finds a place. The true value of authority *per se* is justly weighed, and the evolution and dissolution of things once sacred are so touched as to evidence a decided mastery over historical detail. The chapters on Ethics are lengthy and full to diffuseness in their estimate of the comparative values of the scientific and theologic theories affecting conduct, together with the impersonal entities that frequently control ethics. There is nothing perfunctory—no uncertainty of tone in the treatment of secular as contrasted with ecclesiastical morality. Idealism, realism, intuition, justice, the laws of Nature, and the assumptions that have signally failed to explain ultimate causes, all receive their full quota of consideration.

As if to crown Mr. Bonham's effort we find in his work an entire absence of sensational effect. No temporary expedients of argument are resorted to, and altogether its tone is genuinely altruistic.

In the series of *Correlation Papers* on the several formations of North America, now being issued by the Geological Survey, the third, fourth, fifth, and sixth papers have been published as Bulletins 82 to 85. The third paper has the special title *Cretaceous*, being an examination of the formation of this name, by *Charles A. White*. The chief cretaceous area of the United States is an irregular belt extending from Texas northward through the region of the great plains and continuing into western Canada. There are also small areas in the middle and southern Atlantic coast States. The next paper is on the *Eocene*, by *William B. Clark*. The author finds that the marine faunas of the Atlantic and Gulf coasts permit a separation of the Eocene as a whole from formations belonging to earlier and later periods with a high degree of confidence, but that with present evidence the lines of separation are not sharply drawn among the marine and fresh-water formations of the Pacific coast and the interior region. The *Neocene* is discussed by *William H. Dall* and *Gilbert D. Harris*. Besides assembling the published material concerning its subject, the memoir makes original contributions based on investigations by Mr. Dall. In respect to Florida these contributions are so important that it has seemed best to expand the chapter on that State so as to include practically all that is known of its geologic history. The sixth in this series is by *Israel C. Russell*, on *The Newark System*. This system is confined to a chain of small areas extending from North Carolina to Massachusetts, with a continuation in Nova Scotia. Each of these monographs contains a bibliography and is illustrated, the last one being especially well embellished with colored maps, and its bibliography occupying over two hundred pages.

Three recent Bulletins of the United States Geological Survey embody physical researches by Dr. *Carl Barus*. No. 92 is on *The Compressibility of Liquids*, and embodies results which it is hoped will throw light upon the behavior of the liquid mass underlying the crust of the earth, and the phenomena of upheaval and subsidence of the crust. No. 94 deals with *The Mechanism of Solid Viscosity*, steel and glass being the substances taken for experiment. A paper on *The Volume Thermodynamics of Liquids* appears as No. 96. The results that it contains are confined to volume, pressure, and temperature; questions involving entropy and energy are under investigation. The researches upon which Dr. Barus is engaged were suggested by Mr. Clarence King, who has pointed out the importance of a deeper insight into the volume changes of liquids and solids.

Mr. *Bashford Dean*, of Columbia College, has supplemented his report on oyster culture in France with one describing the methods used in other countries of western Europe, under the title *Report on the European Methods of Oyster Culture*. The topics treated comprise the management of natural oyster grounds, production of seed, rearing young oysters, and the governmental regulation of oyster grounds. The monograph is illustrated with fourteen plates. It forms part of the Bulletin of the United States Fish Commission for 1891.

In Volume XII of the *Transactions of the New York Academy of Sciences* are papers on Dionæa, by Bashford Dean; The North American Species of the Genus Lespedeza, by N. L. Britton; Fact and Fallacy in the Boomerang Problem, by C. H. Emerson; Phosphate Nodules from New Brunswick, by W. D. Matthew; Progress of Chemistry as depicted in Apparatus and Laboratories, by H. C. Bolton; The Sunapee Saibling, by J. D. Quackenbos; Memoir of Prof. J. S. Newberry, by H. L. Fairchild; Petrography of the Gneisses of the Town of Gouverneur, N. Y., by C. H. Smyth, Jr., and the Cretaceous Formation on Long Island and Eastward, by Arthur Hollick. There is a frontispiece portrait of Prof. Newberry.

An extended *Report on the Brown Coal and Lignite of Texas*, prepared by the State geologist, *Edwin T. Dumble*, has been issued. The origin, character, and modes of using brown coal in general are stated in considerable detail, after which the geology, occurrence, and composition of the deposits found in Texas are set forth. Comparisons of the Texas product with European and with bituminous coal follow, and a chapter

on the utilizing of the former completes the volume. The text is illustrated with twenty-five plates and thirteen figures, showing engine grates and grate-bars, briquette presses, the arrangement of certain mines, sections of coal deposits, etc.

A fourth edition of *Standard Tables for Electric Wiremen*, by the late *Charles M. Davis*, revised and edited by *W. D. Weaver*, has been issued (W. J. Johnston Co., New York, $1). The new edition contains the latest revisions of the Insurance Rules of the Underwriters' International Electric Association, also an important section on the calculation of alternating current wiring. A number of the most important tables were prepared expressly for this work, and, being copyrighted, can not be found elsewhere. Among these are the tables of alternating current wiring coefficients, those on limiting currents for exterior wiring and on the candle power of arc lamps, and the table enabling the ones for the three standard lamp voltages to be used for any voltage or drop, as well as several others, including a complete set of wiring tables calculated on a uniform basis of 55-watt lamps.

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POPULAR MISCELLANY.

Reptilian and Amphibian Motions.—M. Marey has extended his time-photographic studies of locomotion to mammals, birds, reptiles, fishes, and articulates. The processes are rather difficult, because they have to be applied to a great variety of movements, and of methods and habits of carrying them on; but it is nearly always possible to assure satisfactory representations by adapting the methods of working to the conditions. The chief difficulty is in getting the animal experimented upon to go at its ordinary gait. This is much more easily accomplished with domesticated animals than with wild ones. By comparing the types which he has got represented, M. Marey discovered some very interesting analogies. Thus, in locomotion on land and on water, he was able to follow the gradual transition between simple "reptation" and the most complicated kinds of locomotion. An eel and a viper, put in water, advance in the same manner; a wave with lateral inflections runs continuously from the head to the tail of the animal, and the velocity of the retrograde movement of the wave is much greater than the speed of translation of the animal. If the animals are set upon the ground, the mode of reptation will be modified in both in the same way. The amplitude of the undulatory movement from one side to the other will be greater, and will increase as the surface on which the animal creeps is smoother. A vestige, more or less pronounced, of the undulatory reptilian movement remains with fish that have fins and reptiles endowed with legs. In the sea-dog, for instance, the retrograde wave running along the whole body is very pronounced. It is considerably reduced in the salmonides, and does not appear except at the tail in fishes the bodies of which are more stubby. This retrograde wave is plainly manifest in the gecko, but less so in some other lizards. The analysis of the varieties of locomotion of the batrachians in the different stages of their evolution is very interesting. The tadpole, for example, exhibits in its earliest stage progression by the undulation of the caudal fin; a mixed type of locomotion comes in with the paws; the tail continues to wriggle, and the hinder limbs make the swimming motions appropriate to them; and the latter movements exist alone for some time after the tail has disappeared. These motions, which so much resemble those of man's swimming, present the peculiarity of the fore legs having no part in them, and of the hind legs, after having been separated so widely as to form a right angle with the axis of the body, approaching one another till they become parallel, then bending and spreading out again to begin a new spring. The motions of lizards' legs are so swift as to escape direct observation, but the successive movements of the fore and hind limbs can be followed in photographs taken forty or fifty times a second. The normal gait of the lizard and the gecko is the trot—that is, their limbs move diagonally. The great amplitude of the motions, combined with the undulation of the axis of the body, causes the limbs on the same side to come very near one another, and then separate widely in the following instant. The lizard projects its hind foot nearly into its armpit on the side on which the body becomes concave; an instant afterward that side becomes convex, the fore leg is carried far forward, and, the body forming a convex arc on that

side, the two limbs are widely separated. Interesting observations have also been made of the motions of insects, arachnida, etc.

Modern Survivals of Primitive Superstitions.—The recently published book of S. Baring-Gould on Strange Survivals furnishes curious suggestions concerning the origin and primary meaning of many customs and practices that have come down to us from remote ages, and which we observe or remark upon without a suspicion of their significance. The superstition has gone out of vogue in civilized lands that the sacrifice of a human being in its foundations is necessary to the stability of any important building. But King Theebaw, of Burmah, in our own days, obeyed it; and the feeling remains among the superstitious in Europe that some unseen power must be propitiated, or it will some time and somehow exact its dues; and numerous legends prevail with reference to grand structures of how the mysterious powers were propitiated in the beginning, or exacted an equivalent for the neglected sacrifice. Only fifty years ago the people of Halle are said to have tried to persuade the builder of a bridge to immure a child in the foundations in order to insure the stability of the piers. The designs of gable ends, carved ridge-tiles, representations of animals, such as horses and horsemen, and the stone balls with which houses are adorned, all have meanings. The completion of a building was signalized by a sacrifice originally, just as the laying of the foundations was. Horses were held to be sacred by the Northern races, and formed, next to a man, the worthiest sacrifice; and if a horse's skull was not put on the point of a gable, a horse's head was carved. At a chieftain's death, his horse was buried with him; and to-day the charger of an officer follows his coffin to the grave. Poles, surmounted by branches of leaves and flowers, protect the farmhouses of the Black Forest from lightning, and represent the ancient oblation of a bunch of grain to Odin's horse; and gables often have carvings connected with this oblation to Odin. At Yuletide oats are thrown out for Santa Claus's horse (the colt of Odin having been transferred to Santa Claus), and a person convalescent after a dangerous illness is said to have "given a feed to Death's horse." The sheaf of corn that is fastened to the gable in Norway and Denmark—now an offering to the birds—was originally a feed for Odin's horse. Formerly, the last bundle of oats in a field was cast into the air by the reapers, for Odin at Yule to feed his horse; and a similar custom prevailed in Devonshire, in Mr. Baring-Gould's recollection. The mediæval habit of affixing the heads of criminals to spikes on battlements was the survival of the offering of skulls to Woden, and the stone balls on the gables of manor houses and on lodge gates are the survival of the right of life and death possessed by the lords of the manor.

"State Socialism" in New Zealand.—At a recent meeting of the Royal Colonial Institute of Great Britain the Earl of Onslow described some experiments in what was called state socialism that had been undertaken in New Zealand. The Government had expended large sums in providing water for mining purposes for working miners, and had given the men the task of repairing the water works, remunerating them, not in money, but in orders for water for the purpose of getting gold. It had worked a system of settling men upon land, with advances of money for house-building and cultivation. In a visit to two of these settlements—one formed by voluntary association, and the other from the unemployed—the speaker had found the voluntary association prosperous, while the unemployed were calling upon the Government to take them out of "the hole" they had been brought into; and he formed the opinion that, while the Government was not in any case without ample security for its advances, yet only careful selection of the land and of the men would secure success. The colony had acquired by purchase, at the owner's valuation, the largest estate in the country, and opened it for settlement; and he believed that, so long as it did not unduly saddle the colony with debt, this experiment in the resumption of the national estate would be likely to prove satisfactory to the Government. The labor department in New Zealand had been more successful than the one abolished last May in Victoria, because numerous country branches had been created instead of calling all the workmen to the central office in the capital. In the system

of co-operation on Government work, the men form themselves into gangs, the strong with the strong and the weak with the weak, so that the weak, although they could not execute work rapidly, were yet not altogether excluded from employment. Two interesting results of the experiment of introducing labor leaders into the Government were noted: when intrusted with power, they became imbued with a sense of responsibility, and could successfully resist the establishment of state charity in the guise of work or unprofitable undertakings, and members of a revising chamber, drawn from whatever party, would resist measures which they believed not to be the deliberate will of the people.

Succession of Arctic Seasons.—In his presidential address before the Geographical Section of the British Association, Mr. Henry Seebohm gave a graphic description, largely drawn from personal experience, of the succession of the seasons in the high arctic latitudes. He said that the stealthy approach of winter on the confines of the polar basin is in strong contrast to the catastrophe which accompanies the sudden onrush of summer. One by one the flowers fade and go to seed, if they have been fortunate enough to attract by their brilliancy a bee or other suitable pollen-bearing visitor. The birds gradually collect into flocks, and prepare to wing their way to southern climes. The date upon which winter resumes its sway varies greatly in different localities, and probably the margin between an early and a late winter is considerable. The arrival of summer happens so late that the inexperienced traveler may be excused for sometimes doubting whether it really is coming at all. When continuous night has become continuous day without any perceptible approach to spring, an Alpine traveler naturally asks whether he has not reached the limit of perpetual snow. It is true that here and there a few bare patches are to be found on the steepest slopes, especially if they have a southern exposure. It is also true that small flocks of little birds may be observed flitting from one of these bare places to another; but their appearance does not give the same confidence in the arrival of summer to the arctic naturalist as the arrival of the swallow or the cuckoo does to his brethren in the subarctic and subtropic climates. The birds seen are only gypsy migrants that are perpetually flitting to and fro on the confines of the frost, continually being driven south by snowstorms, but ever ready to take advantage of the slightest thaw to press northward again to their favorite arctic home. The gradual rise in the level of the river inspires no more confidence in the final melting away of the snow and the disruption of the ice which supports it. In Siberia the rivers are so enormous that a rise of five or six feet is scarcely perceptible. During the summer which the author spent in the valley of the Yenisei there were six feet of snow on the ground. To all intents and purposes it was midwinter, illuminated for the nonce with what amounted to continuous daylight. During May there were a few signs of the possibility of some mitigation of the rigors of winter, but these were followed by frost. At last, when the final victory of summer looked most hopeless, a change took place; the wind turned to the south, the sun retired behind the clouds, mists obscured the landscape, and the snow melted "like butter upon hot toast. . . . The effect on the great river was magical. Its thick armor of ice cracked with a loud noise like the rattling of thunder, every twenty-four hours it was lifted up a fathom above its former level, broken up, first into ice-floes and then into pack-ice, and marched down stream at least a hundred miles. Even at this great speed it was more than a fortnight before the last straggling ice-blocks passed our post of observation on the Arctic Circle; but during that time the river had risen seventy feet above its winter level, although it was three miles wide, and we were in the middle of a blazing hot summer, picking flowers of a hundred different kinds, and feasting upon wild ducks' eggs of various species. Birds abounded to an incredible extent."

Analysis of Volcanic Ashes.—An analysis has been made by M. A. F. Noguès of the ashes and volcanic sands thrown up by the volcano Calbuco, in Chili, during an eruption which began in February, 1893, and had not ceased in December. The fine dust products were projected to places as far off as Moutt, Valdivia, and La Union, at distances varying from twenty-five to one hundred and twelve

miles. They contained no vitreous grains, but simply the minerals that constitute the andesites of which the mass of the mountain is composed, and in the same state as in them. The andesite of the prehistoric eruptions of the region when reduced to powder and traversed by the vapor of water gave the same products as the ashes cast out in 1893 by the volcano. These ashes, therefore, appear to have been derived from the trituration and pulverization of the old lavas of the region without their having been remelted. The author remarks that the eruption of Calbuco has given out such considerable quantities of watery vapor that the usual atmospheric conditions have been materially modified by it. Rains are abnormally abundant even in central and northern Chili, with snows on the mountain chains and the sky covered with clouds—conditions very different from those which normally prevail in the country.

Children's Letters.—The characteristics of children's letters are pertinently described in the London Spectator, which says that the writers "come straight to the point, and get down with it, with a unanimous contempt for self-advertisement, which shows that the dislike to be 'drawn' on matters nearly affecting themselves, which is common to the oldest and wisest of mankind, is fully shown by their youngers and betters. The child is, in this, the father of the wise man. Not that they refuse information. The bare facts are always at the service of the public. They fall into 'common form,' and in a score of letters written by very young children it is difficult to find one in which the decorous reticence as to self is exceeded. Their age, very accurately stated; the number of their brothers and sisters, among whom the last baby naturally takes a leading place; and, possibly, a description of their home, limited, as far as possible, to the information given in their postal address, is evidently considered to be sufficient data from which to form an idea of themselves and their surroundings. Then, in nearly every case, follows a list of the household pets. Judged by the evidence of children, the dog is in every case the most important personage, next to the baby, in the estimation of the nursery. His size, accomplishments, and benevolence, his good or bad temper, and in every case his name, are given with a conscientious and personal interest which is accorded to no other animal. Apparently, there is no limit to the number of pets which the fathers and mothers of our race, whether English, American, or Anglo-Indian, set to the fancies of their children. . . . Looking through a pile of letters from children, mostly girls of all ages from four to thirteen, the writer finds nearly three quarters devoted to careful accounts of dogs, tame mice, a donkey, 'Joey,' a 'ginipig,' 'rabits,' chickens, goats, and innumerable pigeons. There is hardly a word about themselves or their feelings in the whole collection, though the health, wants, and probable sentiments of the animals are treated at great length and with every diversity of spelling. Lists of 'what the pigeons have got'—such as 'the fantail,' two babies and one egg; the 'Jocobin, two eggs,' etc.—are followed by other lists of 'ones that have got nobody.' Chickens are counted before they are hatched and after; and terrible descriptions of the results of a cock-fight, which has made one of the combatants 'all bloddy,' are given at great length, with accounts of the illness, treatment, and burial of other creatures. Events, such as games, parties, or expeditions, are, as a rule, only mentioned, without comment."

Photography of Colors.—The process of photography of colors, discovered a few years ago by M. Lippmann, has been considerably improved, and has now been brought to such a degree of perfection that with it the composite colors of natural objects, such as flags, flowers, and fruits, a multicolored parrot, and a window with four colors, are photographically reproduced. In the hands of M. M. Lumière it has been applied successfully to chromolithographs, natural landscapes, and portraits. The time of exposure required has been reduced from thirty minutes a few months ago to from three to five minutes. While so much has been accomplished in this art, many requirements remain to be fulfilled: the time of exposure to be further reduced; accurate isochromatic plates to be obtained, and a way found of taking proofs on paper. The colored proofs have the property of the old-fashioned daguerreotypes, of not being

clearly visible except when viewed at the right angle. This property, however, has the great advantage that it makes retouching of the picture impossible. To remedy the inconvenience arising from it, M. Lippmann has devised an apparatus for viewing the pictures by the aid of which the proper conditions of the angle can always be obtained.

Toads and Cancers.—Toads were used during the last century as local applications for the cure of cancerous breasts. An account of a cure said to have been wrought by this means is given in Martin's Natural History, published in 1785, from a letter from a physician to the Bishop of Carlisle. The doctor had attended the operation for eighteen or twenty days, and was surprised at the result. The toad was put into a linen bag, all but the head, and that was held to the part. It was supposed to suck the poison till it swelled up and died. Then other toads were put on, and so, till the sore was cured. Sometimes they disgorged, recovered, and became lively again. Other authorities, the writer said, held that the toads did not suck the poison, although they admitted that the swelling and falling off dead was a general consequence of the application. Dr. Leonard G. Guthrie shows, in the Lancet, that a toad can not suck, but when injured or alarmed blows itself up to about twice its ordinary size, and when held and constrained for any length of time in a hot hand, sweats profusely and would probably soon die. The effect of the secretion when held on the hand is to cause dryness, numbness, and a tingling; which it probably did to the cancerous breast, giving a sort of relief to the pain.

A "Sanitary" Building.—Dr. W. Van der Heyden, of Yokohama, Japan, has designed a sanitary building, in which he seeks in winter to imprison the heat-rays of the sun, and in summer to admit the light while excluding the excess of heat; and at the same time to afford perfect ventilation and security against disease germs. The walls of the houses are made of air-tight boxes with sides formed of panes of glass, built upon one another, hermetically jointed with felt, and filled with a solution of alum; the roof is covered with cement. "A house built in such a way is an entirely closed hollow space, like a box itself, without windows or doors—no openings, and no fissures. It is practically impermeable to air, moisture, heat, cold, dust, microbes, and insects." At convenient intervals in the walls of rough plate glass are plates of polished glass, to be used as windows for looking out. "Doors are not wanted, because the entrance can be made through the floor by means of a lift or staircase from an underground room which receives no direct light from the sun. The walls of the underground room are made of ordinary bricks, plastered inside, and protected outside with a thick layer of clay to keep out moisture; it will be better to have these walls constructed with iron plates, as quick conduction of heat is the requisite here. The light for this room comes through glass boxes let in the four corners of its ceiling which forms the floor of the upper room. . . . There is a nice mild diffused light in the lower room which fully enables one to do any laboratory work, and is sufficient to read by." The walls are protected against freezing in winter by inclosing the whole building in a covering of window glass. In the summer the window-glass frames are put within the house, and furnish air cushions, still further preventing the accession of outside heat. Special arrangements are made for the renewal of air, heated in winter and sterilized at all times; and as the house is proof against the entrance of air from any other source, all microbes, disease germs, infections, and insects are efficiently kept out. The author has tried his house, and thinks well of it.

Temperature of the Interior of Trees.—The experiments of M. Prinz on the variations of temperature in the interior of trees seem to show that the sap contains large quantities of gas, which escapes with a sound often quite marked, and which can sometimes be heard two steps away. The mean annual temperature of the interior of a tree corresponds with that of the external air; but the monthly mean sometimes varies by two or three degrees. It usually requires about a day for a fluctuation of temperature to be transmitted to the heart of a tree. While the difference between the interior temperature of a tree and that of the air is

usually only a few degrees, it is sometimes as much as ten degrees; when the temperature of the air falls below the freezing point and continues to fall, the internal temperature of a tree descends to a point near that where water of vegetation freezes and continues there stationary. Water of vegetation freezes a few tenths of a degree below the freezing point of water. The absolute maximum in the interior temperature of a tree trunk may be produced a considerable time before the maximum of the surrounding air, in consequence of the direct action of the spring sun and air on the leafless trees. During the high summer heats the internal temperature of trees is nearly steady at about 15° C., with a variation of two degrees or more, even under exceptional conditions of variation in the temperature of the air. A large tree is usually a little warmer than the air in the cold months, and a little cooler than the air in the warm months.

Anatomy and Physiology for Young Men.—Writing to the projectors of the Quarter-Century testimonial book to Prof. Burt G. Wilder, Dr. Andrew D. White refers to one point on which Prof. Wilder in the early days was able to render a special service outside of his chosen field. "While the university was in its earliest beginnings, a sort of nebulous state, I was impressed by a remark by Herbert Spencer, in his book on Evolution, as regards the relative values of different kinds of knowledge. He named, among the things to be taught to young men, human anatomy and physiology; and his arguments seem to me now to be absolutely conclusive. For apart from the practical part of these studies, they seem to form a most stimulating beginning to study in natural history generally, not perhaps the logical beginning but the best practical beginning, as is shown by the fact that in all ages the great majority of students of note in natural science have been physicians. Under the influence of this impression I asked Prof. Wilder to give a course of lectures every year to the freshman class on anatomy and physiology. Various arguments might have been used against this; it would have been said that, later in their course, students would have been better prepared to appreciate the fine points of such lectures, and the example of all the older institutions might have been pointed to in which such lectures, when given at all, were generally given as a hurried course in the senior year. But the idea of making an impression in favor of studies in natural science, and especially in human anatomy and physiology, just when young men were most awake to receive them, carried the day with me, and hence my request to Dr. Wilder. He acceded to it at once, and for several years, in fact, until the pressure of other duties drew him from this, he continued these lectures, and it turned out that I had builded better than I knew; not only did the lectures produce admirable practical results, not only did they stimulate in many young men and women a love for natural science and give them an idea of the best methods in its pursuit, but they made a most happy *literary* impression upon the students generally; the professor's wonderful powers of clear presentation in extemporaneous lectures proved to be a wonderful factor in literary as well as scientific culture. There was another theory of mine proved to be true by the professor; for I had often felt that mere talks about literature, mere writing of essays, the mere study of books of rhetoric, were as nothing in their influence on the plastic minds of students compared with lectures thoroughly good in matter and manner given in their hearing day after day. Naturally I have always felt exceedingly grateful to Prof. Wilder for proving that theory true and at the same time rendering a great service to his students and to the university."

Preparation of Collections.—In his report of the Department of Botany and Forestry in the State Agricultural College of Michigan, Prof. W. J. Beale gives a list of the more common mistakes which young collectors are apt to make in preparing their collections, the perusal of which may give hints of the manner in which the work should be done. They are: The specimen is a mere "snip" of a thing, one little top, destitute of lower leaves, of roots, and root stalks, instead of enough to fill completely a whole sheet. In many instances the plant is pulled into small pieces, and runners, sterile shoots, old leaves, etc., are thrown away; specimens lack fruit, which is often of more importance

than are the flowers; if tender and young, they are pressed too hard, or later in the season are not pressed sufficiently to make the leaves dry flat. Too many use newspapers for the light sheets on the driers. The printed letters were made with oil, and such spots can take up little moisture. Plants are put in driers which are not thoroughly dried by the heat of the stove or the direct rays of the sun. The old-fashioned press made of tight boards is a clumsy device, but still in use. Plants are not changed two or three times a day on the start, and all this time kept in a warm place—hence the color is not good; they are too long for mounting, and must be broken or cut off or cut in two to fit the sheet of standard size. For the proper methods, novices are referred to certain articles in botanical journals, to a chapter on the subject in Gray's large text-book, "or, better still, to hang about and worry some good collector and see how he does it."

Bathing after Exercise.—The Lancet observes that "the popular notion of the injurious effect of a cold bath taken by one who is overheated from exercise must possess—as all such ideas have—some basis in experience; and yet it is falsified by the experiences of athletes from the days of the Greeks and Romans even until now, who find in this procedure a refreshing and stimulating tonic after the exertion they have recently undergone. And, physiologically speaking, a cold plunge or douche taken immediately after the physical effort, when the skin is acting freely and there is a sense of heat throughout the body, is as rational as in the experience of the athlete it is beneficial. It is paralleled by the tonic effect produced by the cold plunge when the skin is actively secreting after a Turkish bath, and finds its rationale doubtless in the stimulation of the nervous system, in the increase of internal circulation, and also in the renewal of activity to the cutaneous circulation after the momentary contraction of blood-vessels due to the cold. The popular belief, doubtless, rests on the injurious effects which may be induced by the bath in one who does not resort to it immediately, but allows time for the effects of fatigue to show themselves on the muscles and nerves and for the surface of the body to get cool. Taken then, the bath is more likely to depress than to stimulate; there is less power of reaction and greater liability to internal inflammations. At such a time a warm bath rather than a cold one is more suitable and more safe. It has been suggested, however, that the practice of indulging in a bath after violent exercise may initiate renal disease. Of this there is no evidence. The transitory albuminuria observed after prolonged cold baths may indicate the disturbance in the renal circulation which ensues upon them; but these cases are in a different category from those to which we are now alluding, nor are we aware of any facts to prove that, even in them, Bright's disease has been developed in consequence of the transient departure from the normal. Lastly, it must be remembered that those indulging in athletic exercises of all kinds are presumably sound in heart as well as limb, and that such persons may take with impunity and, indeed, with benefit measures which would be distinctly harmful to the weakly."

Recreations for City Children.—Struck by the fact that the present crowding of houses in cities is unfavorable to the free exercise of children in play such as prevailed when man lived in a more scattered way, Prof. S. T. Skidmore, of Philadelphia, has sketched a scheme for the evolution of a new system of play. Even under the prevailing conditions, the way for the development of proper play, he believes, is just as open as for anything else, while its development requires the genius of thought and well-directed business enterprise. The author's plan rests upon the principle that "play is the exercise of the faculties as such; the doing is for the sake of the doing. It is Nature working toward her end in the child by prompting to the free, objectless exercise of those expansile powers which he sees at work in adult life. If he sees the way open and he has the needful facilities, he will imitate so closely, in miniature, the activities of the age to which he belongs, that his play will not be a nuisance, so discordant as to be intolerable; but if left entirely with his own resources, he can do nothing else than drag forward those relics of barbaric play which have descended to him by tradition from barbaric children, who copied the simple

rudenesses of their own barbaric times." So Mr. Skidmore would find his substitute in diversion derived from pursuits, achievements, and habits of the children's elders. "In an age of mechanic arts and commerce, of which the great men are inventors, authors, business organizers, engineers, and self-made millionaires, with the eyes of youth trained upon them in admiration, interested in everything that pertains to their history, and eager to imitate them, it is nonsense to suppose that the boys can not be made to belong to such an age in their play as exactly as the men do in their work." The new play must call forth the constructive faculties, and manual training is held up as an element of it.

Propagation of Cholera.—The report of the Cholera Quarantine Board at Alexandria, Egypt, after reviewing the work of contending against the epidemic last season, inquires into the origin of the disease. According to information received in Egypt, the first cases of cholera were observed among the Yemen pilgrims immediately on their arrival at Mecca. It is known that cholera must have been prevailing in the Yemen as lately as the end of 1892. Discussions on the subject in the past have usually been very unsatisfactory and the conclusions very indefinite. The serious fact remains that cholera epidemics among the pilgrims annually collected at Mecca are of very frequent occurrence and are a standing menace to Egypt and Europe. Four times within the last twelve years the disease might have been introduced by the pilgrims into Egypt or Europe, or both, and the experience of France and Spain has shown how easily it might become endemic. The endeavors of the Quarantine Board have fortunately been successful in stamping out cholera before the pilgrims reached Europe.

NOTES.

BOARDS for making coffins are exported in large numbers from Upper Tonkin to the province of Mongtze, in China. The trees from which they are made are not growing in the woods, but are deposited in what a French writer calls tree mines—that is, they are buried in a sandy soil at a depth of from seven to twenty-five feet, in good preservation, and some of them more than three feet in diameter. They probably once grew, judging from the character and position of the trunks, in a large forest which was buried by an earthquate or some other similar catastrophe. It is impossible to determine when the event took place, for no record of such a phenomenon is preserved; but the time can not have been extremely remote, for the upper limbs of many of the trees are still whole. The tree is a kind of pine, very pitchy, and therefore very durable; whence the demand for it.

THE vibrations of a building or a bridge may be registered by means of a bright gem which will reflect a ray of light upon a sensitive hand moved by clock work. It has recently been found by Dr. Steiner, of Hungary, that the vibrations of a stone bridge while a railroad train is passing over it at a speed of twenty-five miles an hour are much more extensive than had been supposed, and in the fact this author finds a new source of danger.

ACCEDING to a request of the Alpine Club, the Government of India has authorized its officers who are in a position to make them to institute observations of the movements of glaciers in the Himalayas.

A CONSIDERABLE quantity of evidence has been collected of a power in tobacco to destroy the micro-organism of cholera. Herr Wernicke wrapped cultures in cigars, inoculated them with sterile dry and moist unsterilized leaves, immersed them in infusions, and enveloped them in tobacco smoke; and in every case they disappeared in a few hours, except in a five-per-cent infusion, when they lived thirty-three days. Tarsinari found that they were usually killed after thirty minutes' exposure to tobacco fumes. Immunity from cholera has been observed among workmen in tobacco factories.

THE collected works of the chemist Jean Servais Stas are to be published as a mark of honor to his memory, under the direction of MM. Spring and Defaire, in three quarto volumes of about five hundred or six hundred pages each. The first volume will contain the memoirs and papers relating particularly to the determination of atomic weights; the second, notes, reports, and lectures; and the third, posthumous works, relating especially to spectroscopic researches.

CERTAIN concretions or "coal balls" found in the lower coal measures were the subject of a recent paper by H. B. Stocks in the Edinburgh Royal Society. They are remarkable for the perfect condition in which their fossil contents are preserved. Chemically they consist of carbonate of lime and iron pyrites in equal proportions. The perfect condition of the fossilized plant cells and fibers indicates that decay and petrifaction must have gone on simultaneously, and Mr. Stocks accounts for them by supposing that by the process of osmosis water containing

the usual quantity of calcium sulphate in solution passes through the vegetable tissues of the plant and sets up a series of chemical changes resulting in the formation of carbonate of lime and iron pyrites.

INDOLENCE is declared a disease, and its pathology is studied, in the Medical Record. It is found an almost constant indication in albuminuria and diabetes. Malarial fevers induce it, and it is a frequent effect of dyspepsias and indigestions. It is a characteristic in neurasthenia so generally that it is usually safe to say that an indolent person is neurasthenic to a certain extent. Hence, in cases of chronic indolence, the counsels of a physician are often more in place than those of a moralist.

IT has been observed that some of the batrachians have a preference for one or the other of the mediums in which they are capable of existing—the triton, for instance, and the salamander for air, while the frog chooses either, according to the atmospheric conditions, although their morphology points to a descent from a common stock. The subject has been studied by M. Dissart, who, finding that aquatic species transpire more and respire less than land species, concludes that an antagonism exists between the two functions by the operation of which the habitat is determined. If an aquatic species is placed in air, its transpiration is augmented, and it returns to the water to counteract the increase; while if an air species is kept in water, its respiration diminishes and it is obliged to return to the air in order to prevent asphyxia.

THE *telephotos* is the name of a new method of electric signaling by night and day, invented by C. V. Boughton, of Buffalo, N. Y. The theory of it is the production by electricity upon a shaft of incandescent lamps of the symbols of the Morse alphabet and numerals, in dashes five feet long, made with ten lighted lamps, and dots three inches long each, made with one lighted lamp, with unlighted intervals of five feet between each, which would bring under the eye the complete symbol at once. It is intended for use at any points within vision between which the laying of telegraph wires is impossible or impracticable.

THE United States Commission of Fish and Fisheries is engaged in an inquiry, under the direction of George F. Kunz, concerning the locations, yield, and proper protection of fresh-water pearl fisheries in the United States, and in connection with it has sent out a list of questions embracing the subjects of the nature of the stream in which the pearl-bearing mussels are found, kind of bottom, character of water; geological character of the district as to rock, soil, etc.; general abundance of mussels; size, shape, and position of the mussel beds; local names of mussels; habits of mussels; enemies and fatalities to which mussels are exposed; nature and extent of destruction by muskrats, hogs, freshets, etc.; size, shape, and color of mussels; species of mussels in which pearls are most common; proportion of mussels in which pearls occur; sizes or other peculiarities of shells in which pearls are found; nature and origin of pearls; position in mussels; size, shape, and color of pearls; and relative value of pearls of different sizes, shapes, and colors. Other questions relate to the markets and prices for pearls, the method, history, and statistics of the fisheries, the uses made of the mussels after the pearls are taken out, and the exhaustion and replenishment of mussel beds.

AN exceedingly full and rich herbarium and botanical library has been given by Captain John Donnell Smith, of Baltimore, to Johns Hopkins University, on condition that a suitable building be provided for it. The flowering and lower plants of the whole world are represented in the herbarium, which includes Kerner's collection of Austro-Hungarian plants, about thirty individual collections of North American plants, more than a dozen of Central American and Mexican, Lebmann's and nine other collections of South American plants, and representatives from Egypt, Abyssinia, and other parts of the world.

THE palms are said to be the plants possessing the largest leaves. The Quaja palm of the Amazons has leaves approaching fifty feet in length by sixteen feet in breadth. The leaves of some palms in Ceylon are more than eighteen feet long and nearly as wide, and are used by the natives for making tents. The cocoa palm has leaves nearly thirty feet long. In other families than the palms, the parasol magnolia of Ceylon forms leaves large enough to shelter fifteen or twenty persons. One of these leaves, carried to England as a specimen, measured nearly thirty-five feet. The largest leaves grown in temperate climates are those of the exotic *Victoria regia*, which sometimes reach about seven feet in diameter.

ITALIAN grape culturists are now making a very nice illuminating oil from grape seeds, from which they get a product of from ten to fifteen per cent. It is clear, colorless, and inodorous, and burns without smoke.

OBITUARY NOTES.

DR. D. SCOTT MONCRIEFF, of Harvard University, died in Eastern Siberia in August, 1893, while on a journey of exploration and ethnological research. He left a Gilyuk village, near the mouth of the Amur River, for a sail in an open boat on the 11th, and his body was found two weeks afterward on the coast of Sakhalin.